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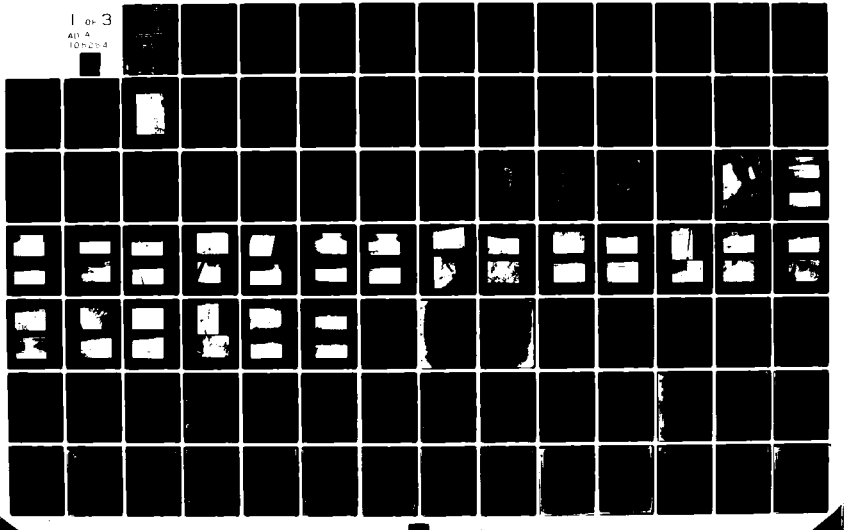

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LAKE THUNDERHEAD DAM

PUTNAM COUNTY, MISSOURI

MO 10007

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

MAY, 1980

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A105254 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Lake Thunderhead (MO 10007) Putnam County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report. / 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Hoskins-Western-Sonderegger, Inc. - Rey S. /Decker Gordon /Jamison Garold /Ulmer Harold P. /Hoskins	8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0071
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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LAKE THUNDERHEAD DAM
PUTNAM COUNTY, MISSOURI
MISSOURI INVENTORY NO. MO 10007

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY
HOSKINS-WESTERN-SONDEREGGER, INC.
CONSULTING ENGINEERS
LINCOLN, NEBRASKA

UNDER DIRECTION OF

ST. LOUIS DISTRICT, CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

MAY, 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

LMSED-P

SUBJECT: Lake Thunderhead Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Lake Thunderhead Dam (MO 10007).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SIGNED

SUBMITTED BY: _____ 17 SEP 1980
Chief, Engineering Division — Date

SIGNED

APPROVED BY: _____ 18 SEP 1980
Colonel, CE, District Engineer — Date

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
ASSESSMENT SUMMARY

Name of Dam	Lake Thunderhead Dam
State Located	Missouri
County Located	Putnam County
Stream	North Blackbird Creek
Date of Inspection	May 6, 1980

Lake Thunderhead Dam was inspected by an interdisciplinary team of engineers ~~from Hoskins-Western-Sonderegger, Inc.~~ The purpose of the inspection was to make an assessment of the general conditions of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

Lake Thunderhead Dam has a height of fifty-four (54) feet and a storage capacity at the minimum top elevation of the dam of twenty-seven thousand four hundred (27,400) acre-feet. In accordance with the guidelines, an intermediate size dam has a height greater than or equal to forty (40) feet but less than one hundred (100) feet and a storage capacity greater than or equal to one thousand (1,000) acre-feet but less than fifty thousand (50,000) acre-feet. The size classification is determined by either the storage capacity or height, whichever gives the larger size category. Lake Thunderhead Dam is classified as an intermediate size dam.

In accordance with the guidelines and based on visual observation, the dam is classified as having a high potential for damage and loss of life. Failure would threaten life and property. The estimated damage zone extends approximately twenty (20) miles downstream of the dam to the confluence of North Blackbird Creek and South Blackbird Creek. Within the first six miles of the damage zone are six dwellings and some outbuildings. Missouri Highway 5 is immediately downstream; Missouri Highway 129 is approximately four miles downstream; and U.S. Highway 136 is about eleven miles downstream. The valley is extensively farmed for its full length.

Our inspection and evaluation indicates that the spillways do not meet the criteria set forth in the recommended guidelines for an intermediate dam having a high hazard potential. The Probable Maximum Flood is the appropriate spillway design flood. The spillways will pass the 100-year flood (1% probability flood - a flood having a one percent chance of being exceeded in any year) without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Construction plans, a soils report and a geological report were available for this dam and are included in this report. Based on the information available from the plans and reports and the observations made during the field inspection, the following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a registered professional engineer experienced in the design and construction of earth dams.

a. Alternatives.

(1) The spillway size and/or the height of dam should be increased to pass the probable maximum flood without overtopping the dam.

b. Operation and Maintenance Procedures.

(1) Stability and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed for appropriate loading conditions including seismic forces. These analyses should be performed by a professional engineer experienced in the design and construction of dams.

(2) Studies should be conducted to determine the source and effects of seepage discharging around the sewage lift station. This may require installation of piezometers and/or closed circuit television inspection of the sanitary sewer line which passes under the reservoir and the dam. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Remedial measures may be required.

(3) The trees growing on the upstream slope as well as the tree growing along the right wall of the principal spillway should be removed under the guidance of a professional engineer experienced in the design and construction of dams.

(4) Additional riprap should be placed on the left end of the dam.

(5) The headcut and gully erosion in the right abutment trough downstream from the berm should be repaired and measures taken to control future erosion in this area.

(6) The slumps and/or slides in the right bank of the scour hole downstream from the principal spillway outlet should be repaired and stabilized.

(7) The concrete deterioration in the headwall of the principal spillway outlet should be repaired.

(8) The grass on the downstream slope should be mowed and measures taken to control the growth and amount of litter that accumulates. Rodent holes or other surface scars revealed by the mowing should be repaired.

(9) The rodent hole along the right wall of the principal spillway outlet should be repaired.

(10) A program of periodic inspection and maintenance should be initiated in order to protect the integrity of the dam.

Rey S. Decker
E-3703

Gordon Jamison

Garold Ulmer
E-19246

H. P. Hoskins

Harold P. Hoskins, Chairman of the Board
Hoskins-Western-Sonderegger, Inc.
E-8696

PHOTO NO. 1 - OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAKE THUNDERHEAD DAM - MO 10007
PUTNAM COUNTY, MISSOURI

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act. Public Law 92-367, authorized the Secretary of the Army through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of Lake Thunderhead Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Dams," dated May, 1975, and published by the Department of the Army, Office of the Chief of Engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth fill approximately 1700 feet in length and 54.4 feet in height. The dam impounds the flow from North Blackbird Creek to form a reservoir covering about 1050 acres. The maximum water storage at the minimum top of dam elevation is 27,400 acre-feet. The dam is located about 3.5 miles north of Unionville, Missouri.

(2) The principal spillway consists of a 7' x 18' reinforced concrete drop inlet (riser) which is connected to a 6' x 7' reinforced concrete box conduit. The spillway is located toward the left end of the dam (Sta. 6+50). The spillway outlets into a reinforced concrete St. Anthony Falls (S.A.F.) type energy dissipator.

(3) A vegetated earth uncontrolled emergency spillway is cut through the left abutment. The crest or control section of the spillway is the asphalt surfaced road that crosses the dam. The width of the emergency spillway at the crest is approximately 200 feet. The spillway outlets into North Blackbird Creek about 450 feet downstream from the toe of the dam.

(4) Pertinent physical data are given in paragraph 1.3 below.

b. Location. The dam is located about 3.5 miles north of Unionville in the north central part of Putnam County, as shown on Plate A-2. The dam is located in Sections 10 and 15, T66N, R19W, as shown on Plate A-1.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Lake Thunderhead Dam has a height of 54 feet and a storage capacity of 27,400 acre-feet. This dam is classified as an intermediate size dam. An intermediate size dam has a height greater than or equal to 40 feet but less than 100 feet and a storage capacity greater than or equal to 1,000 acre-feet but less than 50,000 acre-feet. The size classification is determined by either the storage or height, whichever gives the larger size category.

d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph 1.1c above. Based on referenced guidelines, this dam is in the High Hazard Classification. The estimated damage zone extends approximately twenty miles downstream to the confluence of North Blackbird Creek and South Blackbird Creek. Visual inspection verifies that within the first six miles of the damage zone are six dwellings and some outbuildings. Missouri Highway 5 is immediately downstream; Missouri Highway 129 is approximately four miles downstream, and U.S. Highway 136 is about eleven miles downstream. The valley is extensively farmed for its full length.

e. Ownership. The dam is owned by Chillicothe Properties, Inc., Garry Dickinson, President, Box 784, Chillicothe, Missouri 64601.

f. Purpose of Dam. The dam impounds a 1050 acre recreational reservoir. It also provides flood protection on North Blackbird Creek.

g. Design and Construction History. The dam was designed by W. H. Klingner & Associates, Quincy, Illinois. Portions of the construction plans for the dam are included with this report in Appendix C. The dam was constructed in 1965 by Howard Construction Co., Sedalia, Mo. According to Ms. Quigley, Unionville City Clerk, this project was financed by a loan from the U.S.D.A. Farmers Home Administration (FHA) to the Putnam County Lake Association, Inc.

h. Normal Operating Procedure. The spillways are uncontrolled. According to Mr. Cawley, former Lake Association Manager, the reservoir level is lowered 4 feet every fall to provide additional flood storage and to protect shoreline facilities.

1.3 PERTINENT DATA

a. Drainage Area. 15,580 acres (24.34 square miles). Includes area of Unionville City Reservoir (1.4+sq. mi.).

b. Discharge at Damsite.

(1) All discharges at the damsite are through an uncontrolled reinforced concrete drop inlet (riser) with a reinforced concrete box conduit through the dam and an uncontrolled vegetated earth spillway cut through the left abutment with a bituminous covered road normal to the spillway acting as a weir control.

(2) Estimated maximum flood at damsite - just below crest of emergency spillway according to report by Mr. Cawley.

(3) The principal spillway capacity varies from 0 c.f.s. at elevation 969.0 feet to 1,170 c.f.s. at the cr st of the emergency spillway (elevation 973.0 feet) to 1,370 c.f.s. at the minimum top of dam (elevation 977.4 feet).

(4) The emergency spillway capacity varies from 0 c.f.s. at its crest elevation 973.0 feet to 6,900 c.f.s. at elevation 977.4 feet (minimum top of dam).

(5) Total spillway capacity at the minimum top of dam is 8,270 c.f.s. ±.

c. Elevations. (Feet above M.S.L.)

(1) Observed pool - 968.2
(2) Normal pool - 969.0
(3) Spillway crests
  Principal - 969.0
  Emergency - 973.0 (Minimum, top of roadway)
(4) Maximum experienced pool - 972+
(5) Top of dam (minimum) - 977.4 (Minimum on left end)
(6) Stream bed at centerline of dam - 923±
(7) Maximum tailwater - Unknown

d. Reservoir. Length (feet) of pool.

(1) Principal spillway - 28,000+
(2) Emergency spillway - 32,000+
(3) Top of dam (minimum) - 36,000+

e. Storage (acre-feet).

(1) Observed pool - 15,700±
(2) Normal pool - 16,500±
(3) Spillway crest(s)
Principal - 16,500 ±
Emergency - 21,100 ±
(4) Maximum experienced pool - 20,000 ±
(5) Top of dam (minimum) - 27,400 ±

f. Reservoir Surface (Acres).

(1) Observed pool - 1,000 ±
(2) Normal pool - 1,050 ±
(3) Spillway crest (s).
Principal - 1,050 ±
Emergency - 1,300 ±
(4) Maximum experienced pool - 1,250 ±
(5) Top of dam (minimum) - 1,570 ±

g. Dam.

(1) Type - Rolled earth fill
(2) Length - 1,700 feet ±
(3) Height - 54.4 feet
(4) Top width - 30 feet
(5) Side slopes.
(a) Downstream-1V on 3H (plans) 1V on 3H to 3.4H (measured)
(b) Upstream-1V on 3H (plans) 1V on 3.3H (measured)
(6) Zoning - Homogeneous impervious fill with downstream shell of random fill.
(7) Impervious core - Homogeneous
(8) Cutoff - Located under upstream berm, bottom width = 10 feet, depth varies from 5 feet to 70 feet.
(9) Grout curtain - None
(10) Wave protection - Durable rock riprap
(11) Drains - Blanket and trench drain with perforated corrugated metal pipe.

h. Spillways.

(1) Principal (uncontrolled)
(a) Type. Reinforced concrete drop inlet (riser) with inside dimensions 7 feet wide and 18 feet long (including 8" anti-vortex wall). The reinforced concrete outlet conduit box is 7 feet wide and 6 feet high.
(b) Crest (invert) elevation - 969.0 feet (M.S.L.)
Invert conduit entrance elevation - 954.0 feet (M.S.L.)
Invert conduit outlet elevation - 927.0 feet (M.S.L.)
(c) Length of conduit - 200 feet
(d) Energy Dissipator - St. Anthony Falls (S.A.F.) type

(2) Emergency.

(a) Type - Vegetated earth, uncontrolled, cut through left abutment. Bottom width and side slopes are not well defined.
(b) Control Section - Bituminous road running normal to spillway channel centerline, approximately 20 feet wide.
(c) Crest elevation (minimum top of road) - 973.0 feet (M.S.L.).
(d) Upstream channel - Centerline channel approach to road, 3.7% grade.
(e) Downstream channel - Centerline channel exit from road, 3.1% grade.

i. Diversion Channel and Regulating Tunnel. None.

j. Regulating Outlet. Reinforced concrete box with 14 foot entrance and 4' x 4' conduit. Operated by use of slide gate.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Plans for construction of the dam were supplied by the Lake Owner's Association and are included in Appendix C of this report.

Copies of Geologic Reports, Logs of test holes and Soil Engineering report were provided by W. H. Klingner & Associates and are included with this report in Appendix E.

2.2 CONSTRUCTION

No construction data were available. It was reported by Mr. Cawley, Lake Owner's Association's former manager, that the dam was constructed in 1965 by Howard Construction Co., Sedalia, Missouri. Mr. Cawley worked for the contractor at the time of construction. He reported that the dam was constructed according to the plans and specifications except that the core trench was extended to as much as 70 feet in depth in some areas in order to bottom out in blue glacial clay.

2.3 OPERATION

No data were available on spillway operation. It was reported by Mr. Cawley that the emergency spillway has never operated. The highest reservoir level occurred in 1976 or 1977 when the water reached the level of the roadway across the emergency spillway. Mr. Cawley also reported that the reservoir level is lowered about 4 feet during the fall of each year, by operation of the drawdown facility. Prior to lowering the lake level, the Association alerts about 15 landowners downstream so that they can move equipment and/or animals across North Blackbird Creek before the water comes down.

2.4 EVALUATION

a. Availability. All data was readily available from W. H. Klingner & Associates, the Lake Owners' Association and The Missouri Geological Survey.

b. Adequacy. The available data, field surveys, and visual observation presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. All data provided appears to be valid. However, many of the design recommendations and conclusions presented in Dr. Fry's Soils Report are not supported by test data or engineering analyses.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Lake Thunderhead Dam was made on May 6, 1980. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska making the inspection were: R. S. Decker, Geotechnical; Gordon Jamison and Garold Ulmer, Hydrology. Mr. Harold Cawley, former Lake Owners' Association manager, accompanied the inspection team part of the time.

b. Dam.

(1) Geology & Soils (abutment & embankment) Soils in the area consist of a thin mantle of loess (CL) overlying thick deposits (up to 100 feet) of glacial till. Materials in the abutments consist of stratified glacial till varying in texture from clay (CL-CH) to clayey sands (SC) to sands and gravels. Materials in the valley section consist of alluvial silts and silty clays to depths of 10 to 20 feet, underlain by glacial silty sands and sands to depths of 50 or 60 feet which is underlain by glacial clays (CL-CH). The cutoff across the valley section extends to depths of 70 feet in some places in order to land in CL-CH materials. The embankment is composed of good CL materials borrowed from both abutment areas.

(2) Upstream Slope - The upstream slope looks good. It is well protected with durable limestone and quartzitic sandstone riprap as shown in Photo's 9 and 16. There is some erosion of the abutment at the left end of the riprap that extends 2 or 3 feet above the normal water line as shown in Photo's 7 and 8. A few small trees are growing on the upstream slope. No abnormal deformations or slumps were observed on the slope. Measurements of the exposed portion indicate that the slope is slightly flatter than the 3H on 1V shown on the plans.

(3) Crest. The crest is paved with asphaltic concrete as shown in Photo's 13 and 14. No cracks or abnormal deformations were observed on the crest. Measurements along the crest, shown on Plate (C-32), show crest elevations equal to or slightly higher than shown on the plans. This indicates that anticipated foundation consolidation occurred during construction.

(4) Downstream Slope - The downstream slope, shown in Photo's 17 and 30, is covered with a dense growth of adapted grasses. The cover and vegetative litter is so dense that it obscures most surficial evidence of rodent activity or minor erosions.

One small rodent hole was observed (Photo No. 21), but others could be present. Measurements of the slope presented on Plate C-31 indicate that it is slightly flatter than the 1V on 3H shown on the plans. There is some indication of wetness in the surface drainage ditch along the upstream edge of the berm as shown in Photo's 20 and 38. However, this wetness on the berm appears to be due to imperfect discharge of surface drainage. There were no indications of erosion, bulges, slips or other deformations on the slope. There were no indications of seepage on the slope or along the toe of the principal embankment. However, there is considerable seepage outcropping around the walls of the sewer lift station located downstream from about station 8+00 and about 100 feet right of the principal spillway outlet structure (S.A.F. basin). Plates C-28, C-29 and C-30 show the location and plans for the lift station which will serve the sewer line passing under the reservoir and dam from the west side of the lake. Photo's Nos. 23, 25, 26, 27, and 28 show the seepage around the lift station. The seepy area is very spongey and semi-bouyant. Seepage discharge from the area, part of which is shown in Photo 26, is estimated at about 1 g.p.m. The sewer line into the lift station is not in use and is capped at its termination in the bottom of the station as shown in Photo No. 39. The floor of the lift station is essentially dry as shown in Photo No. 40.

Mr. William's reports, (Appendix E - Division III) in 1972 and 1978, mentions seepage from a terrace on the left abutment. The location of Mr. William's seeps is not known. He may be referring to seeps in the outlet of the emergency spillway channel adjacent to the sewage lagoons as shown in Photo's 36 and 37. (Most of this seepage appears to come from the north lagoon). The seepage outcrops around the lift station at about elev. 940. If this seepage was discharging through the left abutment, it would appear that the weep holes in the principal spillway outlet at elevation 928 and below, would be flowing since the spillway is located between the left abutment and the lift station. It seems likely that the seepage around the lift station originates from or around the sewer line that passes under the dam.

The outlet for the foundation drainage system was not visible (covered with rocks). Discharge from the drain is ponded in the old channel, downstream from the outlet and it was not possible to estimate the quantity (See Photo No. 22).

There was no indication of seepage in the abutment troughs. However, there is a headcut about 6 feet deep and a gully in the right abutment trough that extends from the berm to the toe of the dam. The concrete surface drain down the right abutment trough extends only from the top of the dam to the berm and not to the valley floor as shown on the plans. The sewer line which traverses the berm is exposed in the gully head cut in the right abutment trough as shown in Photo No. 18. Photo No. 19 shows the end of the concrete lined ditch and the headcut at the upper end of the gully.

c. Appurtenant Structures.

(1) Principal Spillway. Measurements of the principal spillway indicate that it was constructed according to the plans. The inlet riser structure, trash rack and drawdown valve appear to be in good condition. No spalling or deterioration was observed in the inlet structure. The inlet is shown in Photo's 10, 11 and 12. The outlet structure shown in Photo's 28 and 33, is generally in good condition. Some spalling was noted in the concrete headwall of the spillway conduit as shown in Photo No. 31. Weep holes in the outlet structure are operating as shown in Photo No. 34. A cottonwood tree is growing immediately adjacent to the right wall of the S.A.F. basin. A large rodent hole was observed adjacent to the tree on the right wall of the S.A.F. basin. Photo's 28 & 29 show the tree and rodent hole. Some slumping and seepage was noted in the right bank of the earth channel just downstream from the outlet structure as shown in Photo No. 32. All seepage was clear and no boils were observed. This seepage could be associated with the seepage described around the lift station.

(2) The emergency spillway is well vegetated with adapted grasses as shown in Photos 3, 4, 5 and 6. (No slumps, erosion or deformations were noted in the spillway). The asphaltic roadway across the dam crosses the spillway and serves as the crest or control section of the spillway. The spillway has never operated. Some seep areas were observed toward the lower end of the outlet channel as shown in Photo No. 36. Discharge was clear and too small to estimate. A considerable amount of seepage was observed along the left side of the outlet channel, adjacent to the north sewage lagoon. Most of this seepage appears to originate from the lagoon(s). Seepage discharge from this area was clear and estimated at 2 to 3 g.p.m. The emergency spillway channel discharges into the exit channel for the principal spillway. Emergency spillway discharges should not encroach upon the dam.

(3) Drawdown Facilities. The drawdown facility consists of a 4 ft. x 4 ft. conduit outletting into the principal spillway riser. It is controlled by a rising stem slide gate located in the upstream wall of the riser. The facility appears to be in good condition. It is operated every fall of the year to draw down the reservoir level. The drawdown gate valve is shown in Photo No. 12.

d. Reservoir Area. The reservoir is surrounded by grassland and woods. Some erosion is evident around the shoreline, but it does not appear to be serious.

e. Downstream Channel. The old stream channel has been partially filled and now serves only as an outlet for the toe drain. The two spillways outlet into an excavated channel which is clear of obstructions and pretty well stabilized with rock riprap as shown in Photo No. 35. This channel enters the old North Blackbird Creek channel about 450 feet downstream from the toe of the dam.

3.2 EVALUATION

This structure appears to be constructed as shown on the plans presented in Appendix C. The structure is generally in good condition. It appears to be structurally stable against shear failure. The source and potential detrimental effects of seepage around the lift station should be investigated. Deterioration of the concrete headwall around the principal spillway outlet could become serious unless it is repaired. The tree and rodent hole observed along the principal spillway outlet structure should be removed and the area restored. The headcut and gully in the right downstream abutment trough could ultimately result in considerable damage to the dam if not repaired. The few small trees should be removed from the upstream face and the erosion at the left end of the riprap should be controlled. Tree removal should be done under the guidance of a professional engineer experienced in the design and construction of dams.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool level is primarily controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillways. However, the drawdown facility is opened during the fall of each year, and the reservoir level is lowered about 4 feet below the principal spillway crest elevation. This provides additional flood protection and reduces potential damage to shore installations during the winter and spring runoff periods. Some 15 landowners and/or operators are notified prior to lowering the lake level so that livestock and equipment can be transferred across the North Blackbird Creek before the creek rises.

4.2 MAINTENANCE OF DAM

At the present time there does not appear to be any regular maintenance on the structure. Mr. Cawley reported that up until about four (4) years ago the downstream slope and emergency spillway was mowed twice a year, trees were removed, and other general maintenance work was performed.

4.3 MAINTENANCE OF OPERATING FACILITIES

The drawdown facility appears to be maintained in satisfactory condition.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in effect for this dam.

4.5 EVALUATION

A program of regular maintenance needs to be established so that corrective measures can be taken prior to problems becoming major in scope. Most of the deficiencies observed during the field inspection can be attributed to the lack of regular maintenance. The lowering of the lake each fall should be continued.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Plans for the dam, as prepared by W. H. Klingner and Associates, Consulting Engineers, Quincy, Illinois, were obtained from the Lake Owners' Association.

b. Experience Data. The drainage area, reservoir surface area, and elevation-storage data were developed from the USGS Lake Thunderhead and Unionville West, Missouri 7 1/2 minute topographic quadrangle maps and other data prepared by W. H. Klingner & Associates and presented in the Plans shown in Appendix C. The hydraulic computations for the spillway and dam overtopping discharge ratings were based on plan specifications and data collected in the field at the time of the field inspection.

c. Visual Observations.

(1) The principal spillway appears in good condition except for the spalling of the concrete at the headwall at the downstream end of the reinforced concrete box conduit. There is some shoreline erosion at the entrance to the emergency spillway. Otherwise it appears to be in good condition.

(2) The emergency spillway, exit channel and the transverse asphalt surfaced road across the spillway channel appear to be in good condition. Spillway releases will not endanger the integrity of the dam.

(3) Riprap on the upstream face of the dam is excellent.

d. Overtopping Potential. The spillways are too small to pass the probable maximum flood without overtopping. The spillways will pass the 1% probability flood as well as 40% of the probable maximum flood without overtopping the dam. Overtopping by the probable maximum flood could be expected to result in erosion of the crest and embankments and subsequent failure of the dam.

The results of the routings through the dam are tabulated in regards to the following conditions:

Frequency	Inflow Discharge c.f.s.	Outflow Discharge c.f.s.	Maximum Pool Elevation	* Maximum Depth Over Dam Feet	Duration Over Top Hours
1/2 PMF	29,200	12,600	978.4	1.0	7
PMF	58,600	45,400	981.6	4.2	13
0.40 PMF	23,500	8,100	977.4	0	--

*Minimum top of dam elevation - 977.4

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard rating and an intermediate size. Therefore, the Probable Maximum Flood is the test for the adequacy of the dam and its spillway.

The estimated damage zone is described in Paragraph 1.2d in this report.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation. This dam appears to be structurally stable from the standpoint of shear strength. The side slopes are slightly flatter than planned, and there are no signs of distress. The source of seepage around the lift station and its effect on stability is not known. If the source of the seepage is related to the placement and/or the integrity of the sewer line under the embankment, this seepage could impair the integrity of the dam through piping and excessive uplift if it is left uncontrolled.

b. Design and Construction Data. The structure appears to be constructed in accordance with the plans provided by W. H. Klingner & Associates. Shear strength and other analytical parametric data were not available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available which is considered a deficiency. Construction data were not available. However, Mr. Cawley, who worked for the contractor at the time of construction, reported that the contractor followed the construction specifications. The specifications for Class I fill called for 95% of maximum ASTM D698 at moisture contents of optimum $\pm$ 2%.

c. Operating Records. No operating records were available. Mr. Cawley reported that the reservoir is lowered 4 feet each fall through the drawdown facility. He also reported that the emergency spillway has not operated.

d. Post Construction Changes. A 6-inch cast iron pipe waterline and a 10-inch clay pipe sewer line were installed along the downstream berm of the embankment in 1968 or 1969. Plans for these lines are shown on Plates C-27, C-28, C-29 and C-30. Installation of these service facilities on the berm do not appear to have any adverse affect upon the stability of the dam. Photo No. 24 shows one of the manholes for the sewer line across the berm.

e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of the magnitude predicted in this area is not expected to cause structural failure of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. This structure appears to be in relatively good condition. Stability and seepage analyses were not available which is considered a deficiency. The source and effects of seepage discharging around the lift station downstream from about station 8+00 should be determined. Several deficiencies in maintenance were noted and should be corrected. These include: lack of mowing (or other control) of the heavy grass cover on the downstream slope; erosion in the right abutment trough downstream from the berm; concrete deterioration in the outlet headwall of the principal spillway; tree growth and rodent activity along the right wall of the principal spillway outlet; tree growth on the upstream face; and some erosion in the abutment at the termination of the riprap on the left end of the dam and apparent accumulation of surface drainage along the upstream side of the berm. Analyses performed for this report indicate that the spillways will pass the 1% probability flood and about 40% of the PMF without overtopping the dam. These analyses include inflow that would result from breaching the Unionville City Reservoir, located just upstream from this reservoir. Overtopping by the probable maximum flood could be expected to result in erosion of the crest and embankments and subsequent failure of the dam.

b. Adequacy of Information. The conclusions in this report are based upon performance history and visual observations. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available which is considered a deficiency.

c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2b should be accomplished in the near future. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Further Investigations. The additional studies and analyses recommended in paragraph 7.2 should be accomplished by the owner in the near future.

e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to be hazardous to this dam. It is recommended, however, that the prescribed seismic loading for Seismic Zone 1 be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a registered professional engineer experienced in the design and construction of earth dams.

a. Alternatives.

(1) The spillway size and/or the height of dam should be increased to pass the probable maximum flood without overtopping the dam.

b. Operation and Maintenance Procedures.

(1) Stability and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed for appropriate loading conditions, including seismic forces. These analyses should be performed by a professional engineer experienced in the design and construction of dams.

(2) Studies should be conducted to determine the source and effects of seepage discharging around the sewage lift station. This may require installation of piezometers and/or closed circuit television inspection of the sanitary sewer line which passes under the reservoir and the dam. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Remedial measures may be required.

(3) The trees growing on the upstream slope, as well as the trees growing along the right wall of the principal spillway, should be removed under the guidance of a professional engineer experienced in the design and construction of dams.

(4) Additional riprap should be placed on the left end of the dam.

(5) The headcut and gully erosion in the right abutment trough downstream from the berm should be repaired and measures taken to control future erosion in this area.

(6) The slumps and/or slides in the right bank of the scour hole downstream from the principal spillway outlet should be repaired and stabilized.

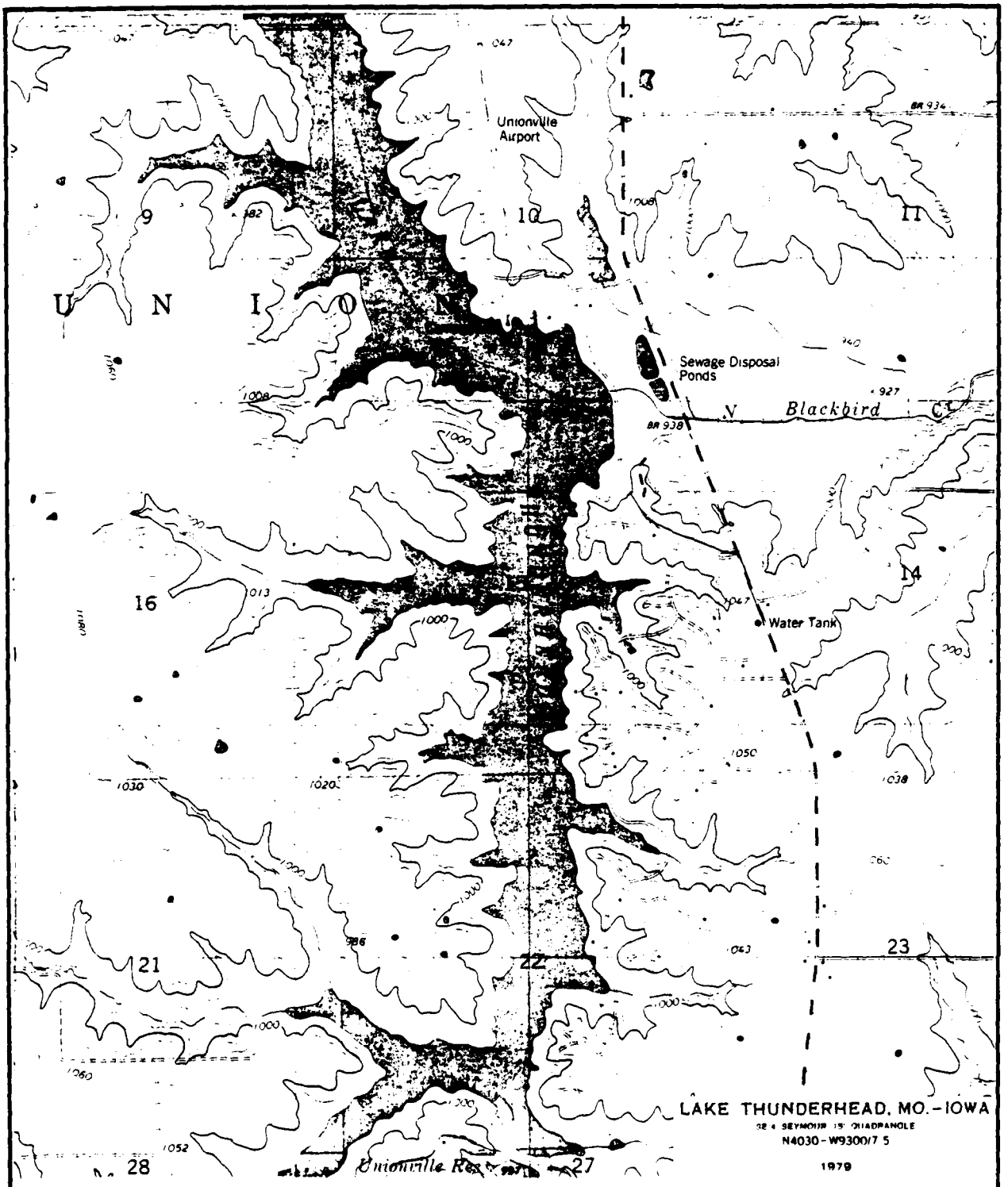
(7) The concrete deterioration in the headwall of the principal spillway outlet should be repaired.

(8) The grass on the downstream slope should be mowed and measures taken to control the growth and amount of litter that accumulates. Rodent holes or other surface scars revealed by the mowing should be repaired.

(9) The rodent hole along the right wall of the principal spillway outlet should be repaired.

(10) A program of periodic inspection and maintenance should be initiated in order to protect the integrity of the dam.

APPENDIX A
MAPS



Scale in feet

2000 1000 0 2000 4000

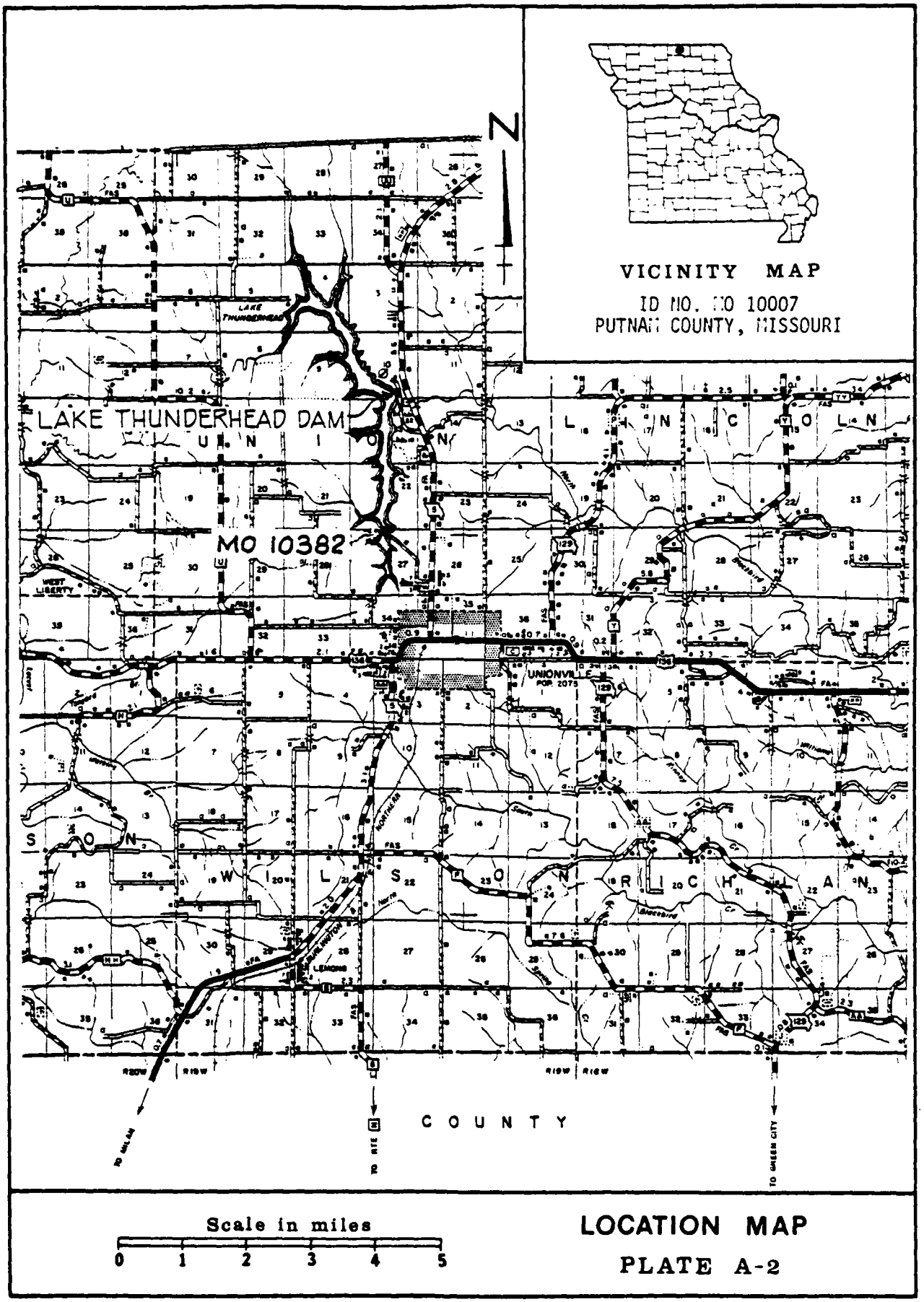
Contour Interval - 10'

N

VICINITY TOPOGRAPHY

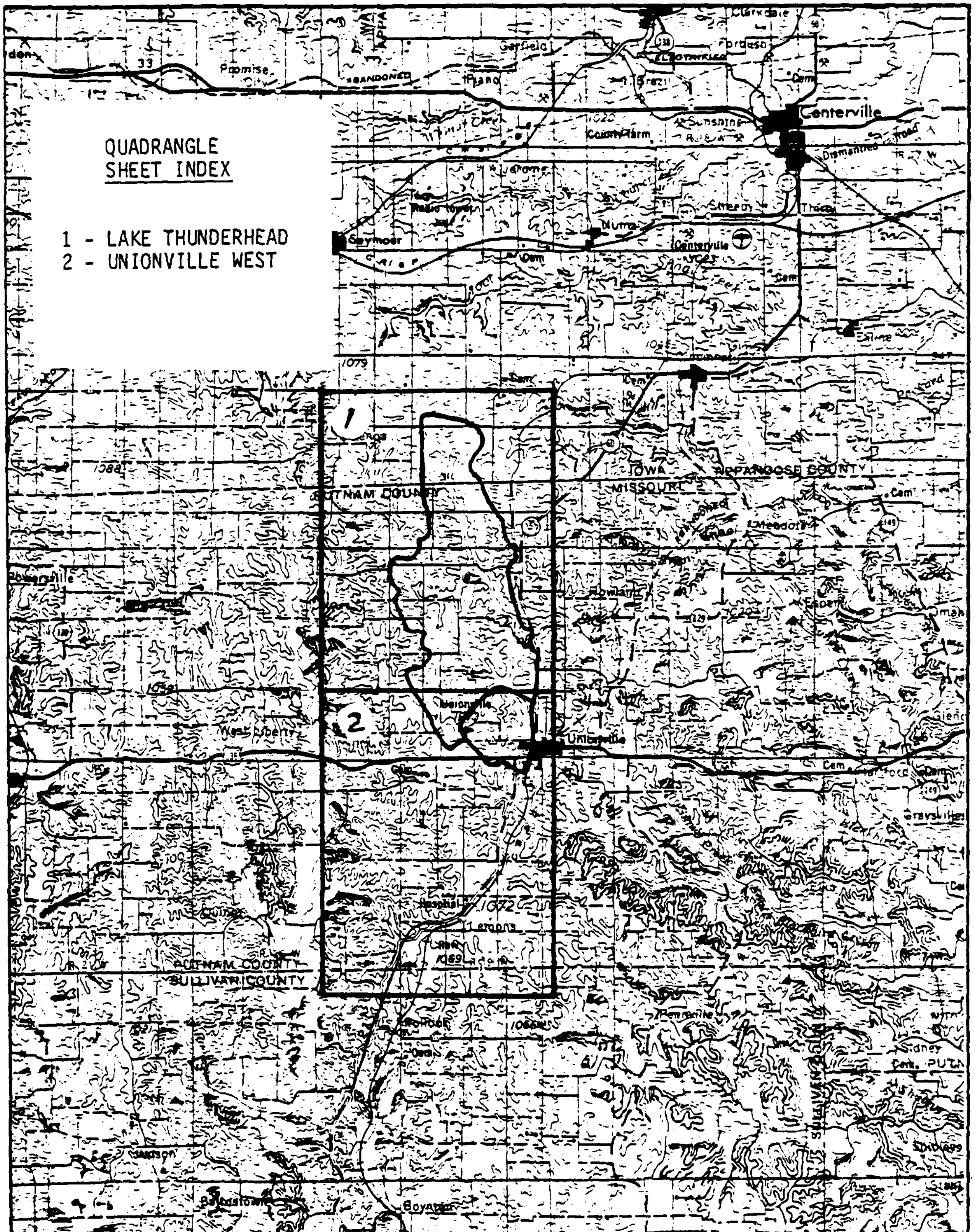
LAKE THUNDERHEAD DAM
PUTNAM COUNTY, MISSOURI
MO 10007

PLATE A-1



LOCATION MAP

PLATE A-2



LAKE THUNDERHEAD DAM

PUTNAM COUNTY, MISSOURI

MO 10007

DRAINAGE AREA MAP

PLATE A-3

APPENDIX B
PHOTOGRAPHS

LAKE THUNDERHEAD DAM
PUTNAM COUNTY, MISSOURI
MO 10007

PHOTO INDEX

PLATE B-1

PHOTO NO. 2 - OVERVIEW OF DAM FROM UPSTREAM ON LEFT ABUTMENT

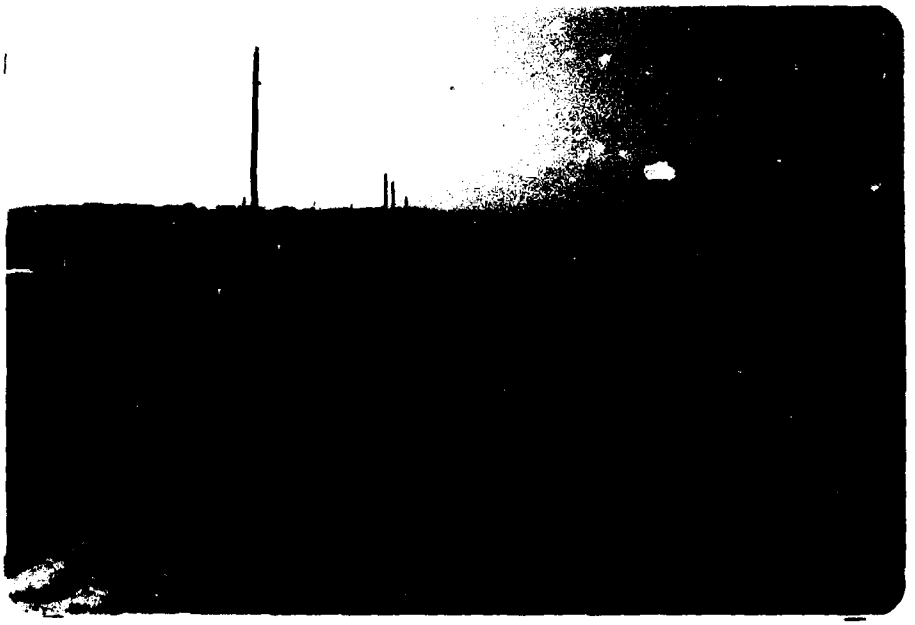


PHOTO NO. 3 - EMERGENCY SPILLWAY CREST TAKEN FROM LEFT END

PHOTO NO. 4 - VIEW UPSTREAM IN EMERGENCY SPILLWAY

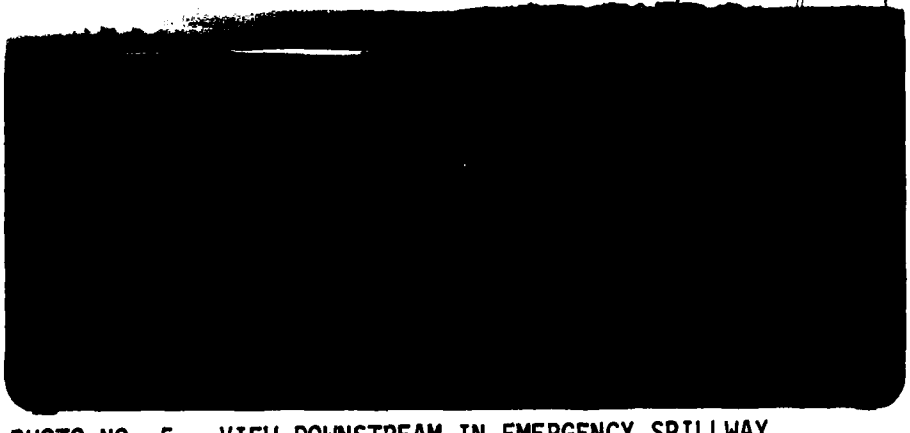


PHOTO NO. 5 - VIEW DOWNSTREAM IN EMERGENCY SPILLWAY

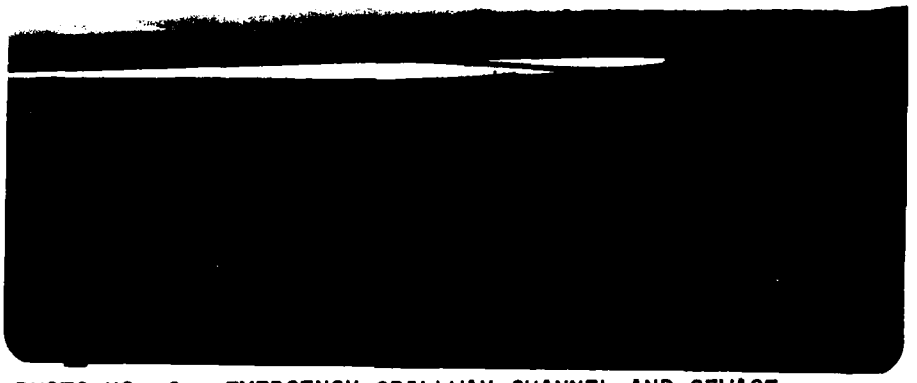


PHOTO NO. 6 - EMERGENCY SPILLWAY CHANNEL AND SEWAGE LAGOONS FROM LEFT END OF DAM

PHOTO NO. 7 - EROSION ON UPSTREAM SLOPE NEAR BEND IN CENTERLINE ON LEFT END

PHOTO NO. 8 - UPSTREAM FACE FROM LEFT END

PHOTO NO. 9 - UPSTREAM FACE AND CREST TAKEN FROM LEFT OF CURVE IN CENTERLINE LOOKING SOUTH

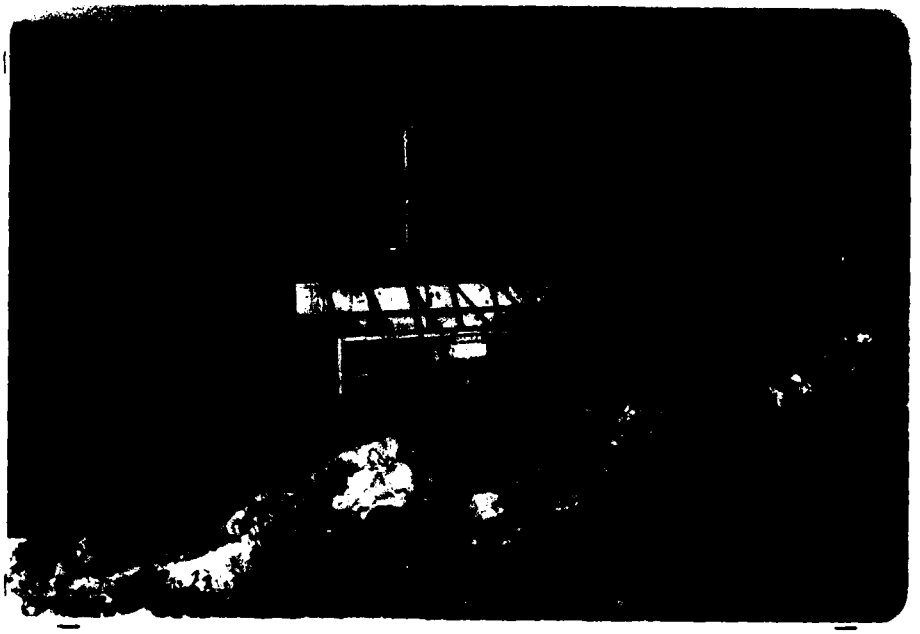


PHOTO NO. 10 - VIEW UPSTREAM WITH PRINCIPAL SPILLWAY INLET IN FOREGROUND

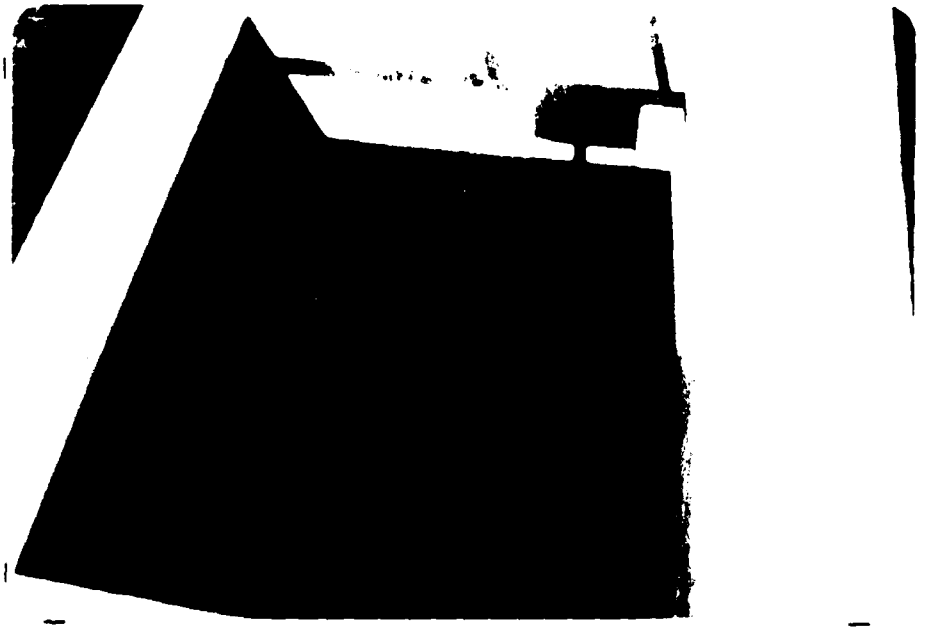


PHOTO NO. 11 - DOWNSTREAM BAY OF PRINCIPAL SPILLWAY INLET

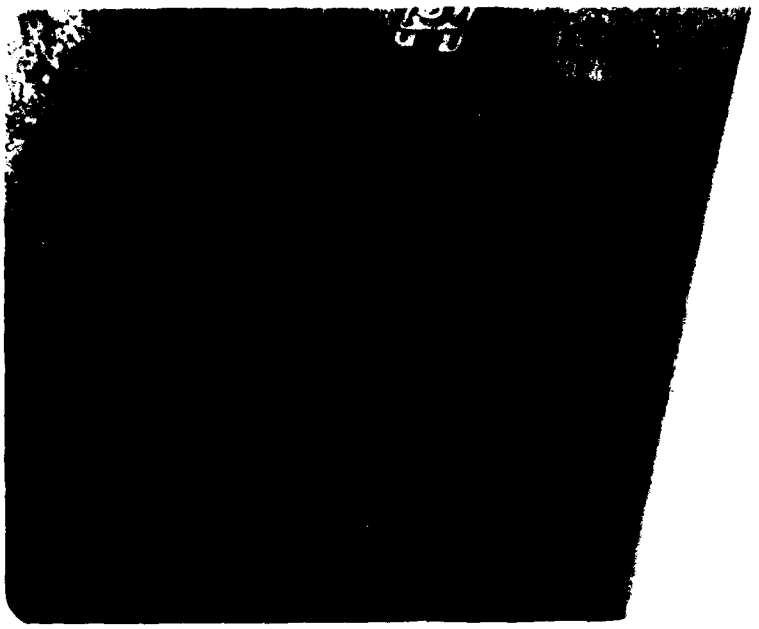


PHOTO NO. 12 - UPSTREAM BAY OF PRINCIPAL SPILLWAY INLET SHOWING SLIDE GATE

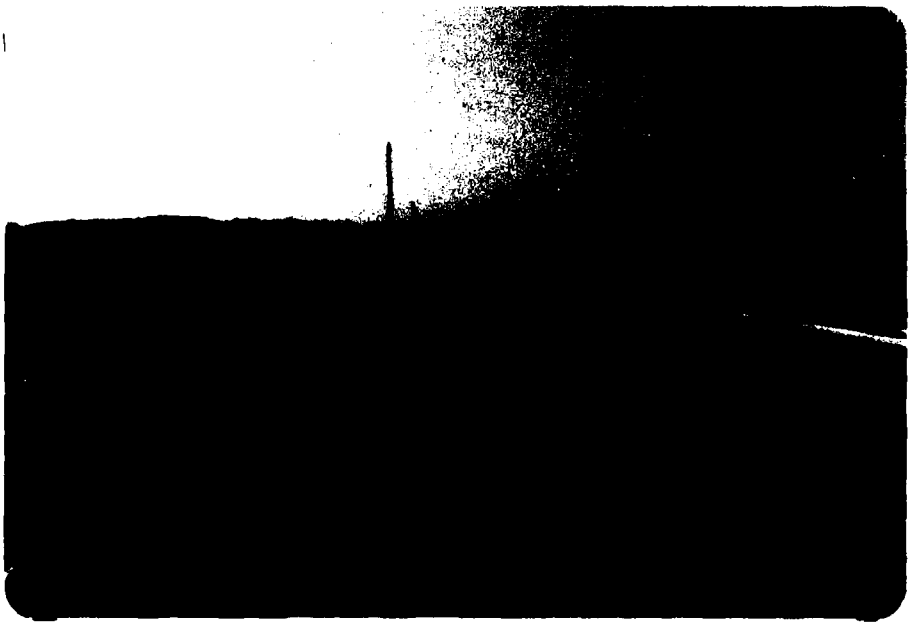


PHOTO NO. 13 - CREST FROM CURVE TOWARD LEFT END LOOKING SOUTH

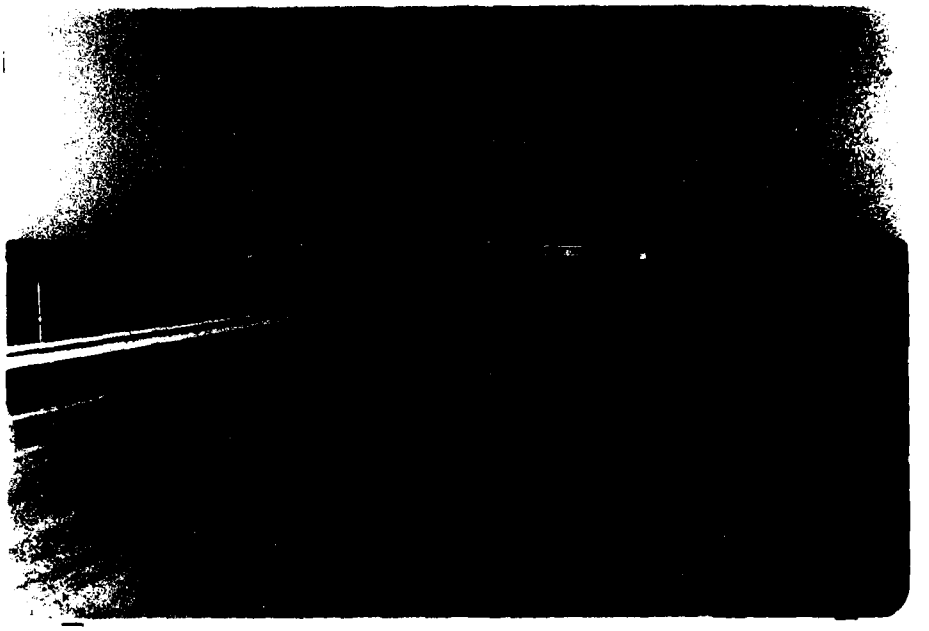


PHOTO NO. 14 - CREST FROM CURVE IN DAM LOOKING NORTH

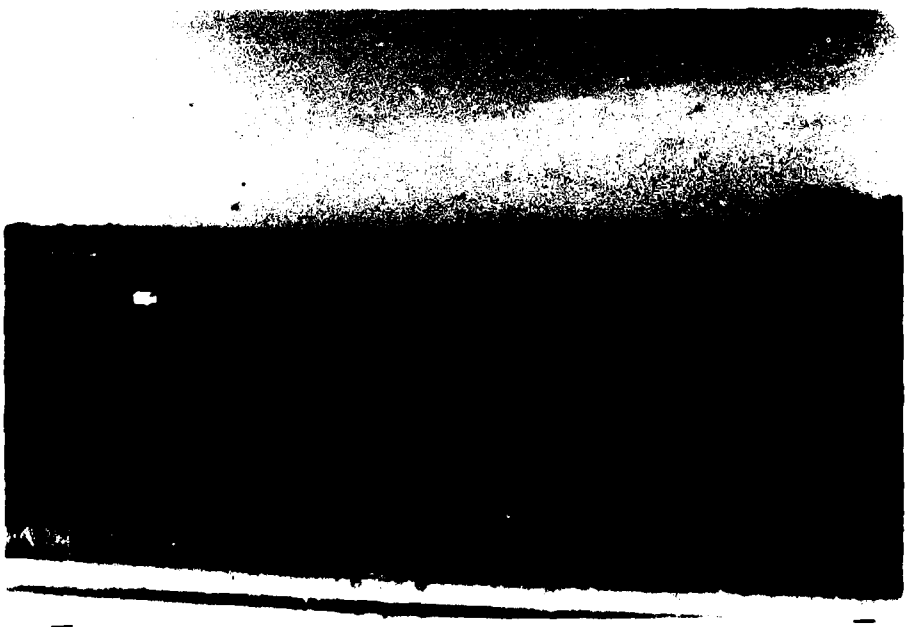


PHOTO NO. 15 - VIEW DOWNSTREAM SHOWING OLD CHANNEL AND HIGHWAY BRIDGE IN BACKGROUND

PHOTO NO. 16 - UPSTREAM FACE FROM RIGHT END

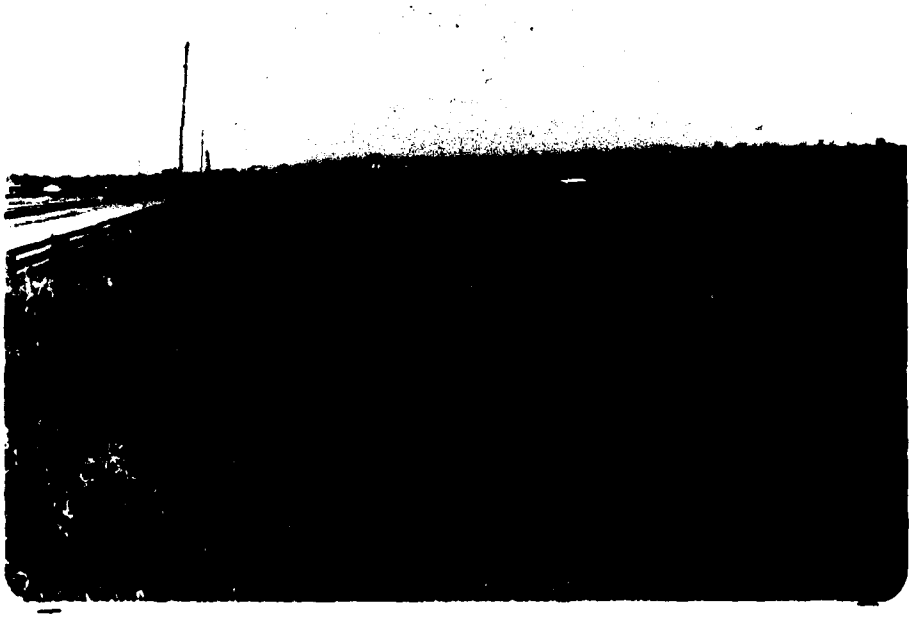


PHOTO NO. 17 - DOWNSTREAM FACE FROM RIGHT END

PHOTO NO. 18 - GULLY ERODED IN RIGHT ABUTMENT TROUGH DOWNSTREAM FROM BERM

PHOTO NO. 19 - CONCRETE LINED DITCH IN RIGHT ABUTMENT TROUGH. GULLY BEGINS AT END OF LINED DITCH

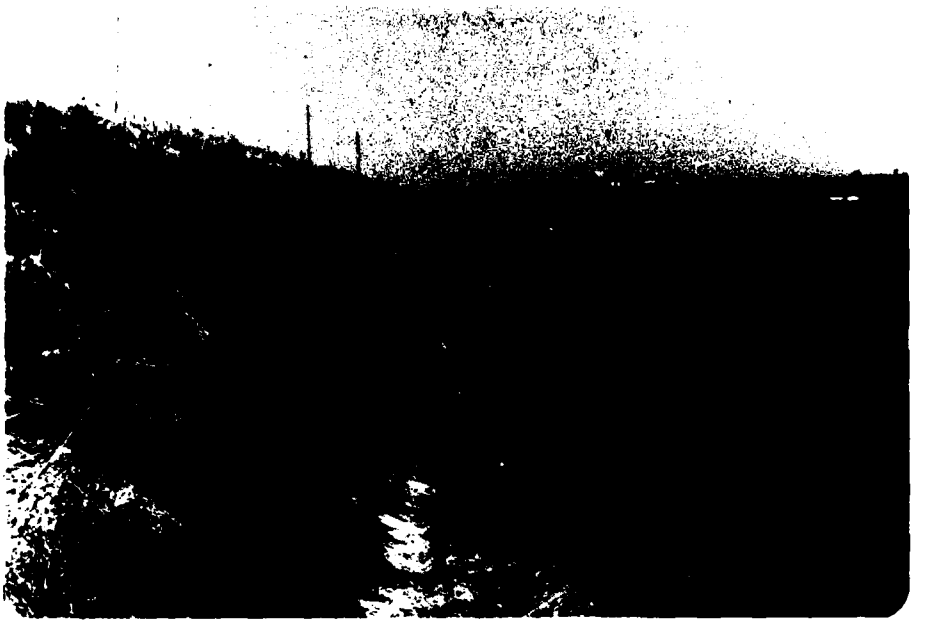


PHOTO NO. 20 - CATTAILS AND WILLOW TREE (BACKGROUND) GROWING IN DITCH IN BERM

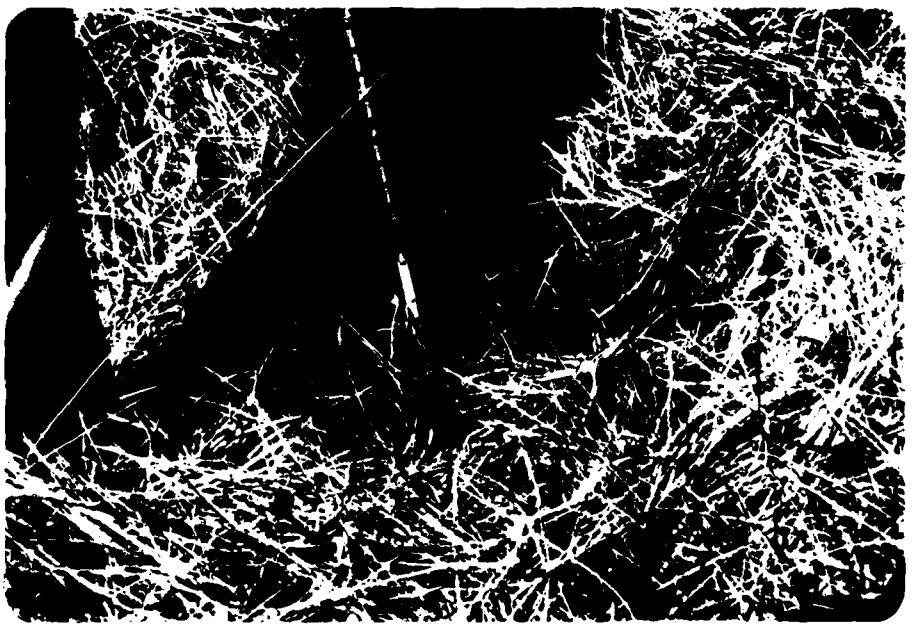


PHOTO NO. 21 - SMALL RODENT HOLE IN DOWNSTREAM SLOPE

PHOTO NO. 22 - VIEW DOWNSTREAM IN OLD CHANNEL. WATER IS THE DISCHARGE FROM TOE DRAIN

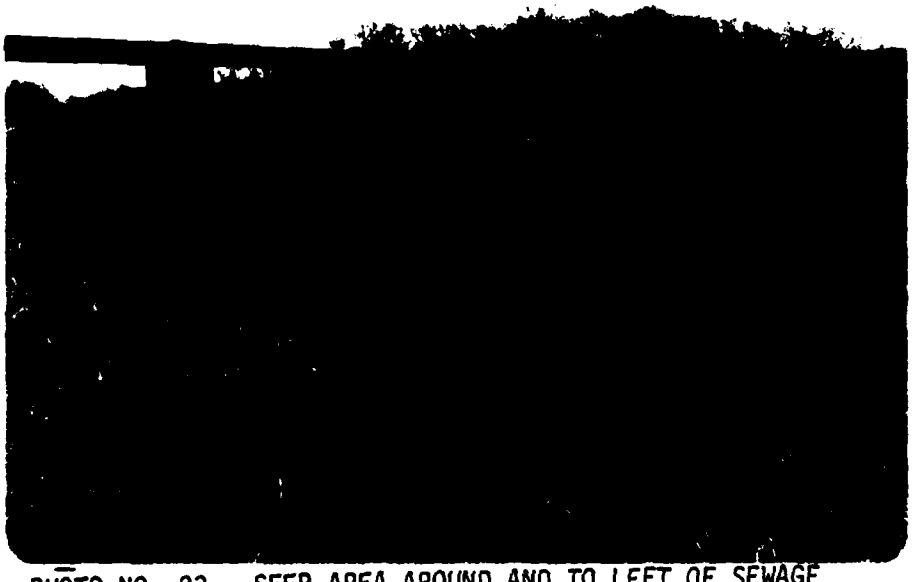


PHOTO NO. 23 - SEEP AREA AROUND AND TO LEFT OF SEWAGE LIFT STATION

PHOTO NO. 24 - MANHOLE ON SANITARY SEWER CROSSING THE BERM

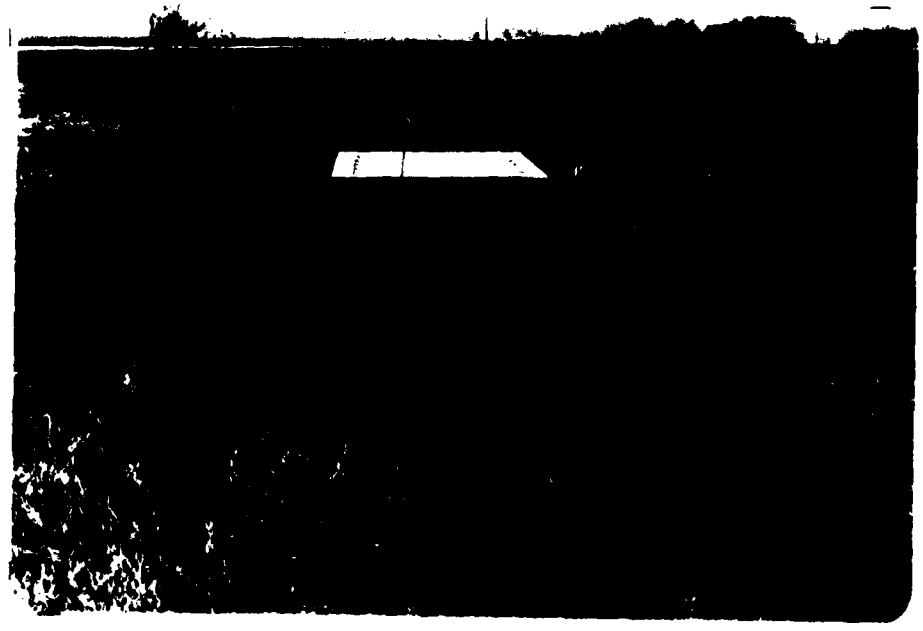


PHOTO NO. 25 - SEEP AREA AROUND LIFT STATION. VIEW LOOKING EAST

PHOTO NO. 26 - SEEPAGE DISCHARGE FROM LIFT STATION AREA. LIFT STATION IN BACKGROUND

PHOTO NO. 27 - SEEPAGE AROUND UPSTREAM SIDE OF LIFT STATION

FORM 1

PHOTO NO. 28 - PRINCIPAL SPILLWAY OUTLET WITH LIFT STATION AND SEWER LINE TO RIGHT

PHOTO NO. 29 - TREE AND RODENT HOLE AT RIGHT SIDE OF SPILLWAY CHUTE

PHOTO NO. 30 - DOWNSTREAM SLOPE FROM EMERGENCY SPILLWAY CHANNEL. LIFT STATION AND SEWER LINE ON LEFT

PHOTO NO. 31 - SPALLING OF CONCRETE IN PRINCIPAL SPILLWAY OUTLET

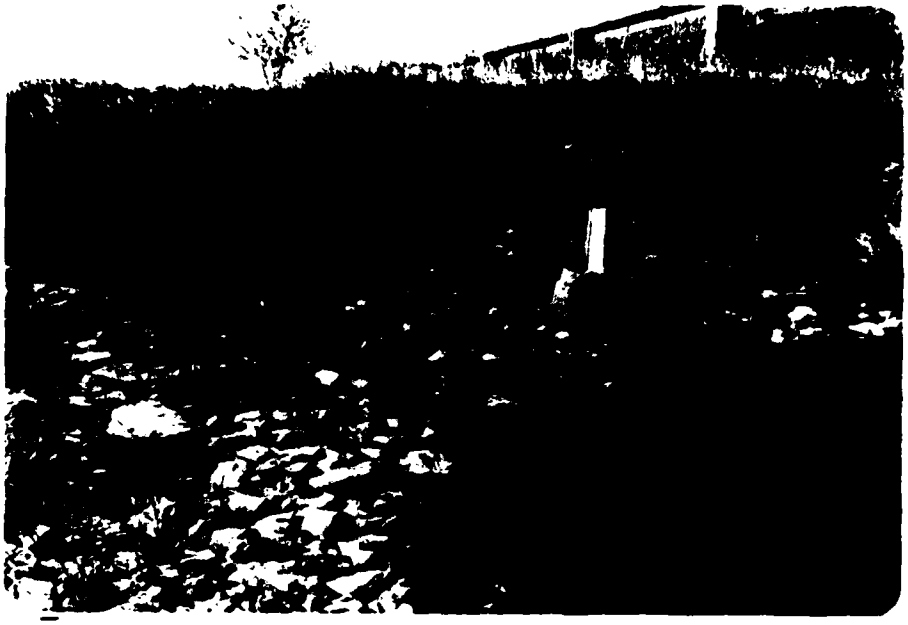


PHOTO NO. 32 - SCOUR AND SLUMPS IN RIGHT SIDE OF PRINCIPAL SPILLWAY SCOUR HOLE. PIPE IS DRAIN FROM LIFT STATION

PHOTO NO. 33 - OUTLET OF PRINCIPAL SPILLWAY

PHOTO NO. 34 - WEEP HOLES IN LEFT WALL OF PRINCIPAL SPILLWAY OUTLET CHANNEL

PHOTO NO. 35 - LOWER END OF OUTLET CHANNEL FOR PRINCIPAL SPILLWAY

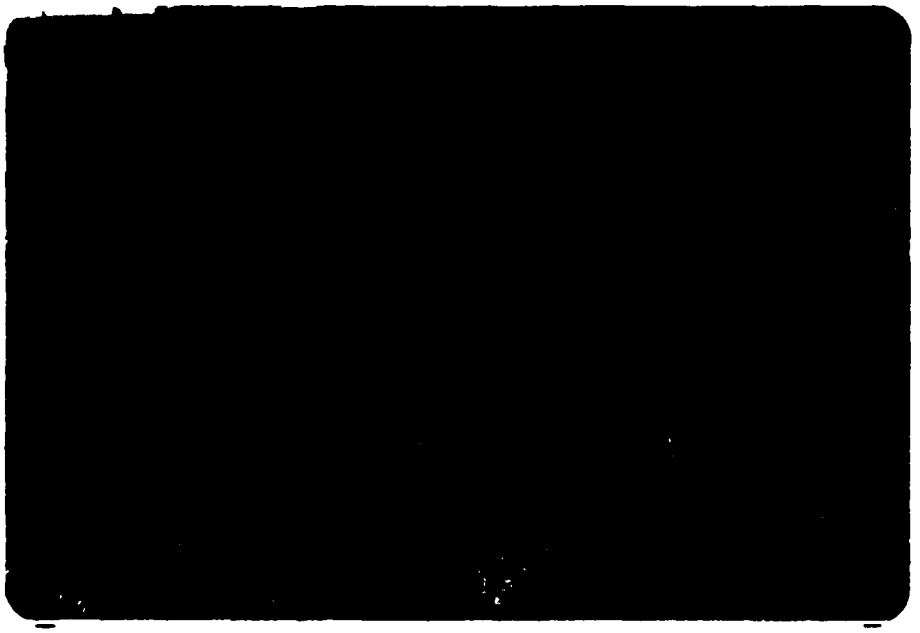


PHOTO NO. 36 - SEEP IN OUTLET CHANNEL OF EMERGENCY SPILLWAY. CATTAILS GROWING ALONG BASE OF SEWAGE LAGOONS

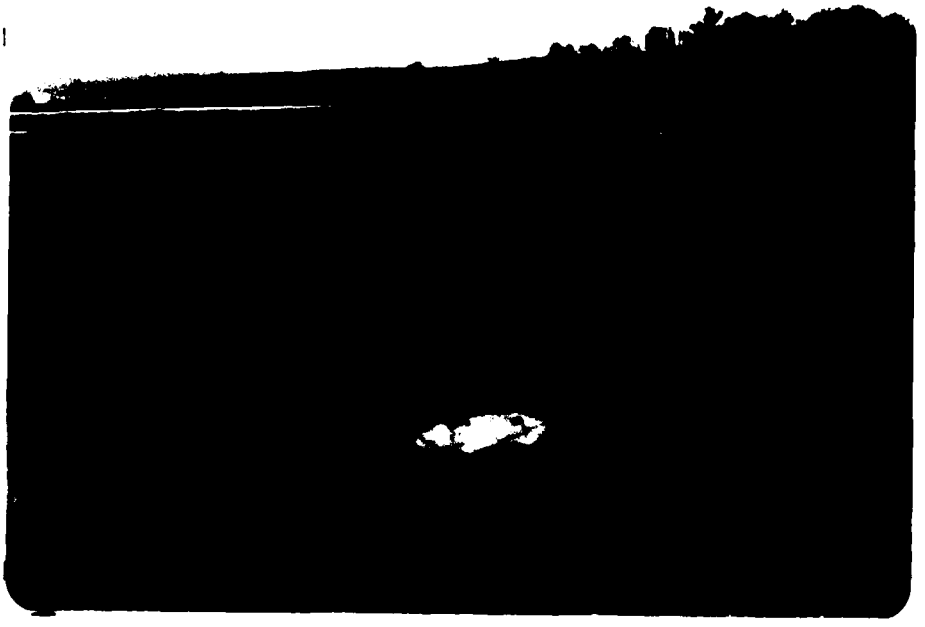


PHOTO NO. 37 - SEEPAGE FROM SEWAGE LAGOONS

PHOTO NO. 38 - SURFACE DRAIN DITCH ALONG BERM

PHOTO NO. 39 - CONNECTION OF SEWER LINE UNDER DAM WITH LIFT STATION

FORM 1

PHOTO NO. 40 - OUTLET FOR DRAIN IN BOTTOM OF LIFT STATION. DRAIN PIPE OUTLET SHOWN IN PHOTO NO. 32

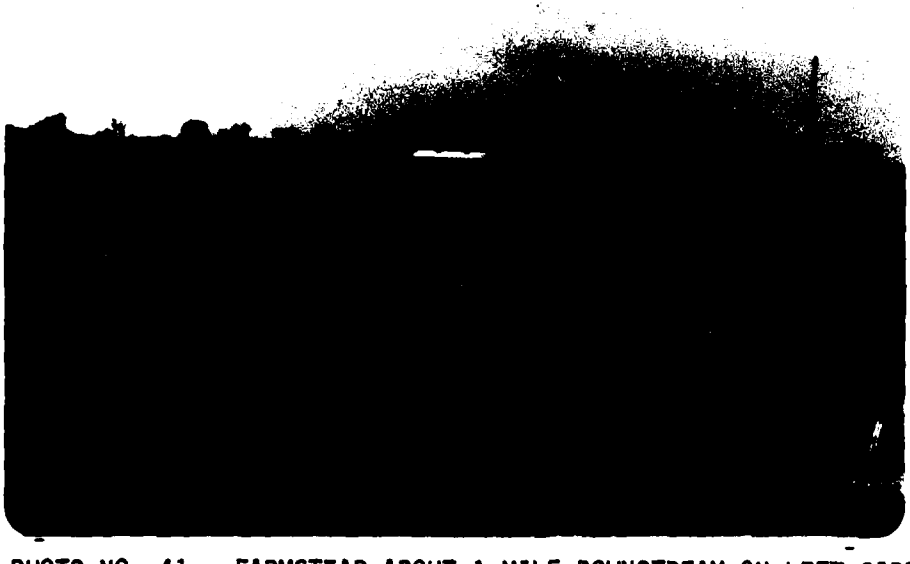


PHOTO NO. 41 - FARMSTEAD ABOUT 1 MILE DOWNSTREAM ON LEFT SIDE OF NORTH BLACKBIRD CREEK. PHOTO TAKEN LOOKING NORTH FROM CREEK.

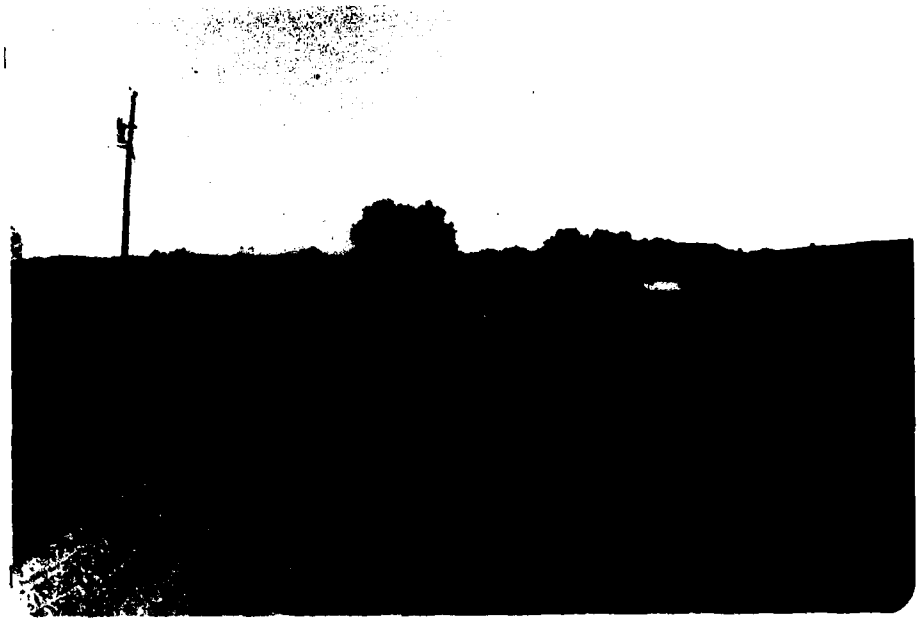


PHOTO NO. 42 - FARMSTEAD SHOWN IN PHOTO NO. 41. PHOTO TAKEN LOOKING SOUTH TOWARD FLOOD PLAIN

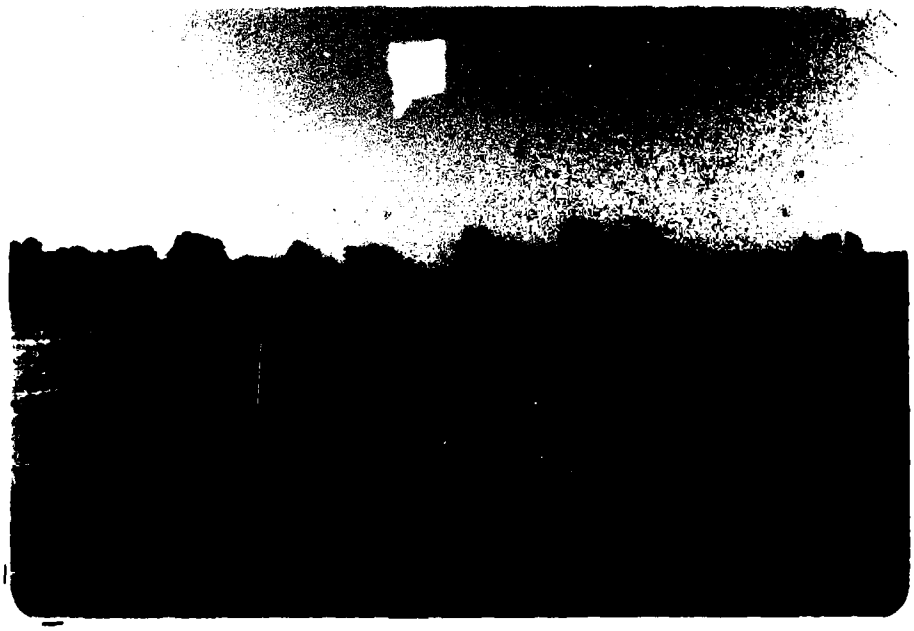


PHOTO NO. 43 - FARMSTEAD ON RIGHT SIDE OF NORTH BLACKBIRD CREEK APPROXIMATELY 1 MILE DOWNSTREAM.

APPENDIX C
PROJECT PLATES

PUTNAM COUNTY LAKE

UNIONVILLE, M

RECREATIONA

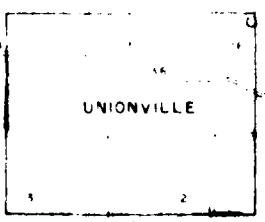
DIRECTORS

LLOYD NORRIS	PRESIDENT
HENRY FELDMAN	VICE PRESIDENT
W. E. ROSS	TREASURER
DON SHUEY	SECRETARY
FLOYD ANDERS	MEMBER
PAUL CLARK	MEMBER
GILBERT STAGGS	MEMBER
CLEO WEBBER	MEMBER
H. WILLARD ARNAMAN	MEMBER

LAKE ASSOCIATION, INC.

LLE, MISSOURI

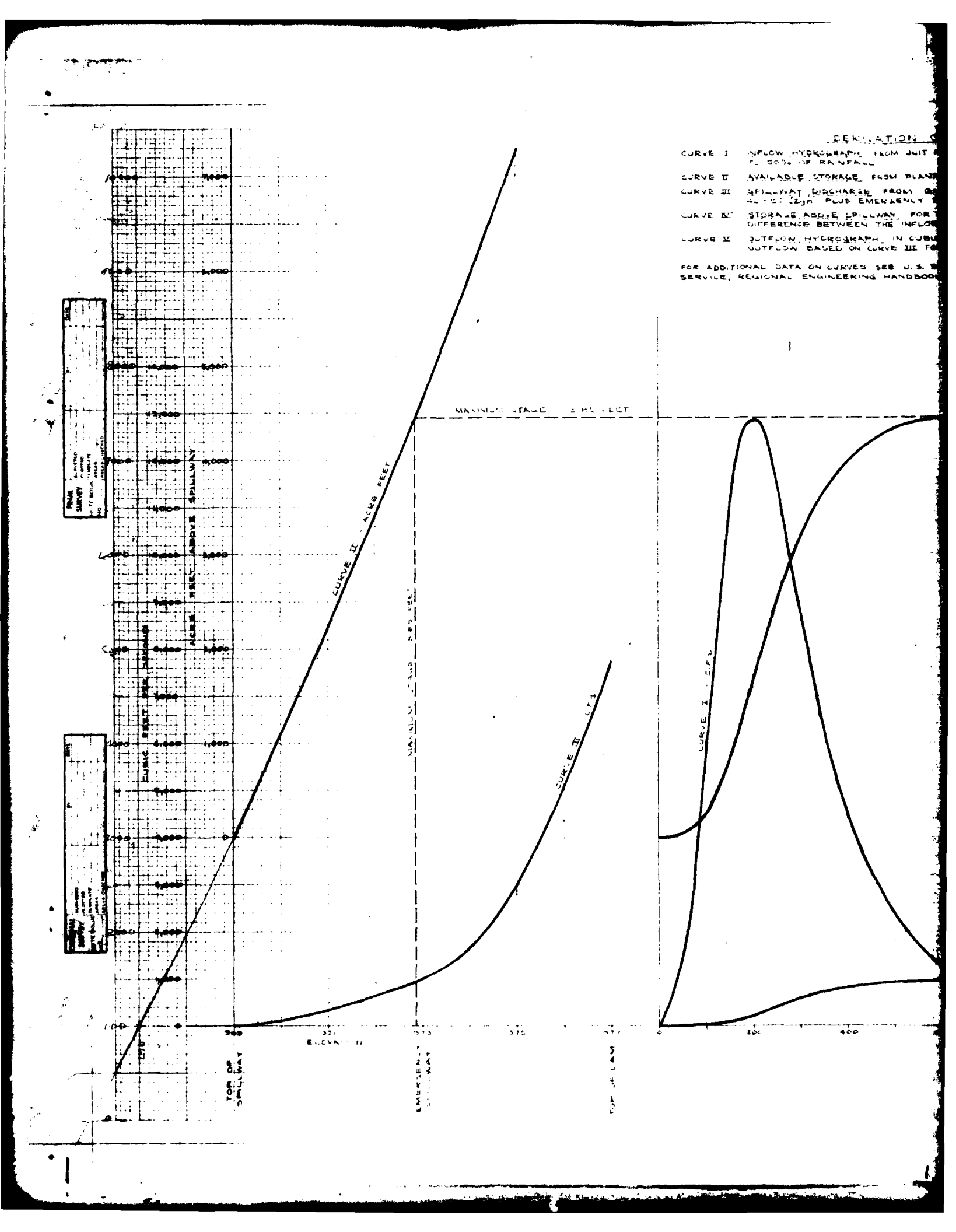
TIONAL LAKE



INDEX OF SHEETS

SHEET NO.	DESCRIPTION
1	COVER SHEET
2	HYDRAULIC DESIGN DATA
3-4	SITE PLAN-CLEARING
5	LOG OF TEST BORINGS
6	GENERAL PLAN OF DAM SITE
7	TOE DRAIN - PLAN AND PROFILE
8-10	DAM CROSS SECTIONS
11	ROAD THROUGH BORROW AREA - PLAN AND PR
12-15	ROAD THROUGH BORROW AREA - CROSS SEC
16	EMERGENCY SPILLWAY - CROSS SECTIONS
17	PLAN OF SPILLWAY DITCHES
18	SPILLWAY DITCHES - CROSS SECTIONS
19	MISCELLANEOUS DETAILS
20	MECHANICAL SPILLWAY AND OUTLET WORKS
21-23	OUTLET STRUCTURE
24-25	OUTLET CONDUIT
26-27	INLET STRUCTURE
28	INLET CONDUIT

PREA
W. H. KLINGNER
CONSULTING ENGINEER


DERIVATION
CURVE I INFLOW HYDROGRAPH FROM UNIT
CURVE II AVAILABLE STORAGE FROM PLAN
CURVE III SPILLWAY DISCHARGE FROM
CURVE IV STORAGE ABOVE SPILLWAY FOR
DIFFERENCE BETWEEN THE INFLO
CURVE V OUTFLOW HYDROGRAPH IN CUBI
OUTFLOW BASED ON CURVE III F
FOR ADDITIONAL DATA ON CURVES SEE U.S.
SERVICE, REGIONAL ENGINEERING HANDBOO
MAXIMUM STAGE
CURVE II - ACRE FEET
CURVE III - C.F.S.
CURVE I - C.F.S.
CUBIC FEET PER SECOND
ACRE FEET ABOVE SPILLWAY
ELEVATION
TOP OF SPILLWAY
EMERGENCY SPILLWAY
TOP OF DAM

DERIVATION OF CURVES

GRAPH FROM UNIT HYDROGRAPH METHOD USING TOTAL RUNOFF EQUAL RAINFALL

STORAGE FROM PLANIMETER OF CONTOURS WITHIN LAKE AREA

DISCHARGE FROM $Q = 3.1LH^{3/2}$ BUT NOT TO EXCEED 12.4 L (length) OR PLUS EMERGENCY SPILLWAY ABOVE ELEVATION 873.0 $Q = 3.1L(H-5)^{3/2}$

THE SPILLWAY FOR EACH TIME INTERVAL IS A GRAPHIC PLOT OF THE DIFFERENCE BETWEEN THE INFLOW AND OUTFLOW FOR THAT TIME.

HYDROGRAPH IN CUBIC FEET PER SECOND IS A GRAPHIC PLOT OF THE RUNOFF BASED ON CURVE III FOR EACH STAGE OF STORAGE ABOVE THE SPILLWAY.

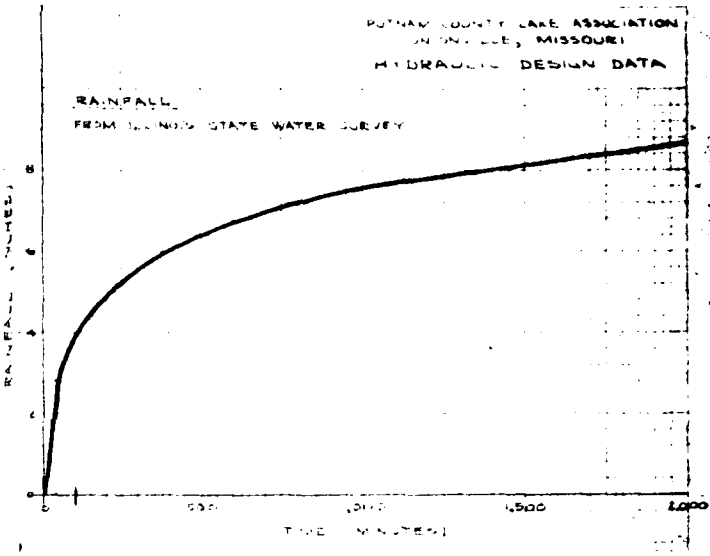
CURVES SEE U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION ENGINEERING HANDBOOK DESIGN DATA #2

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

HYDRAULIC DESIGN DATA

RAINFALL

FROM ILLINOIS STATE WATER SURVEY



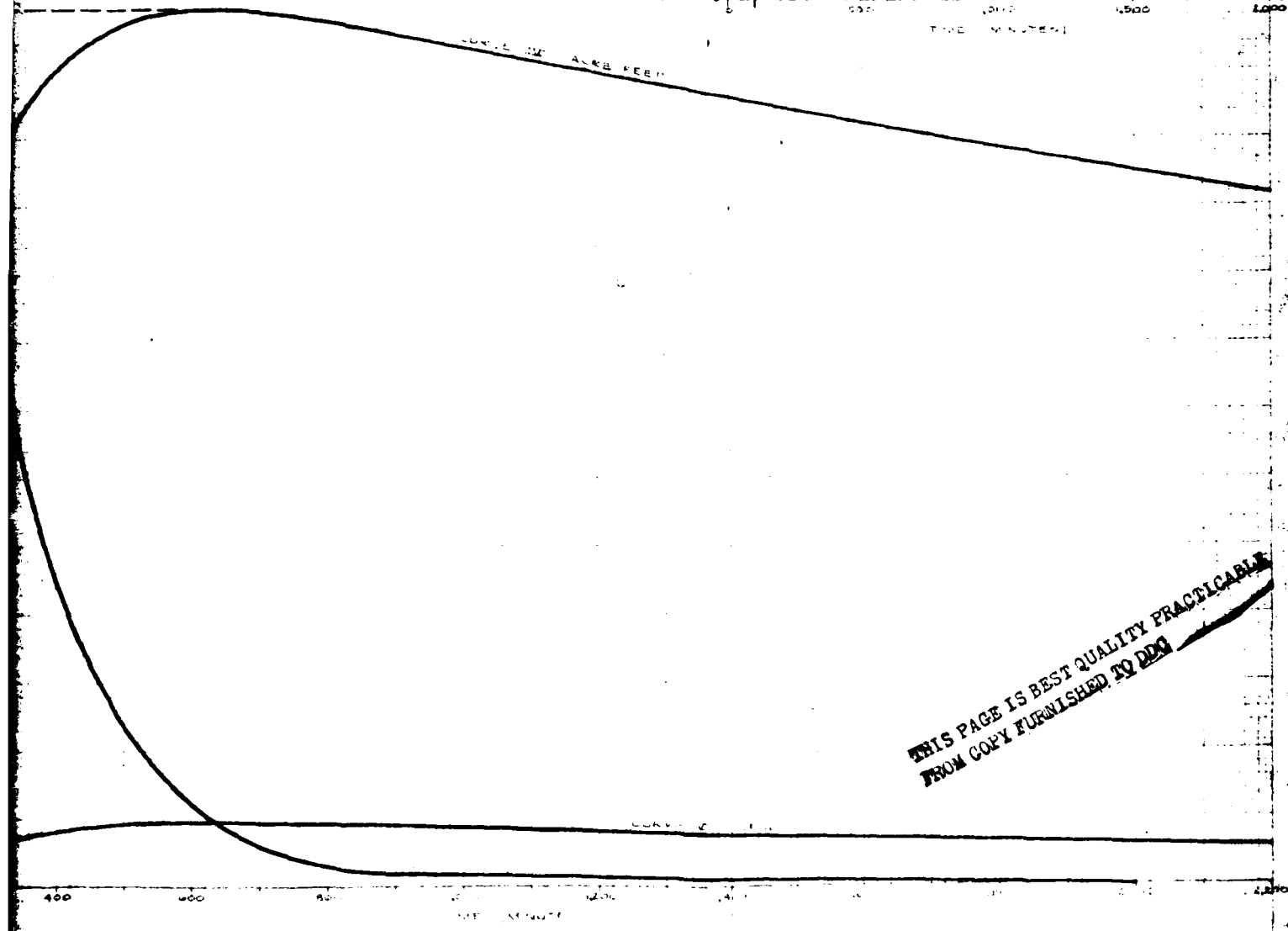
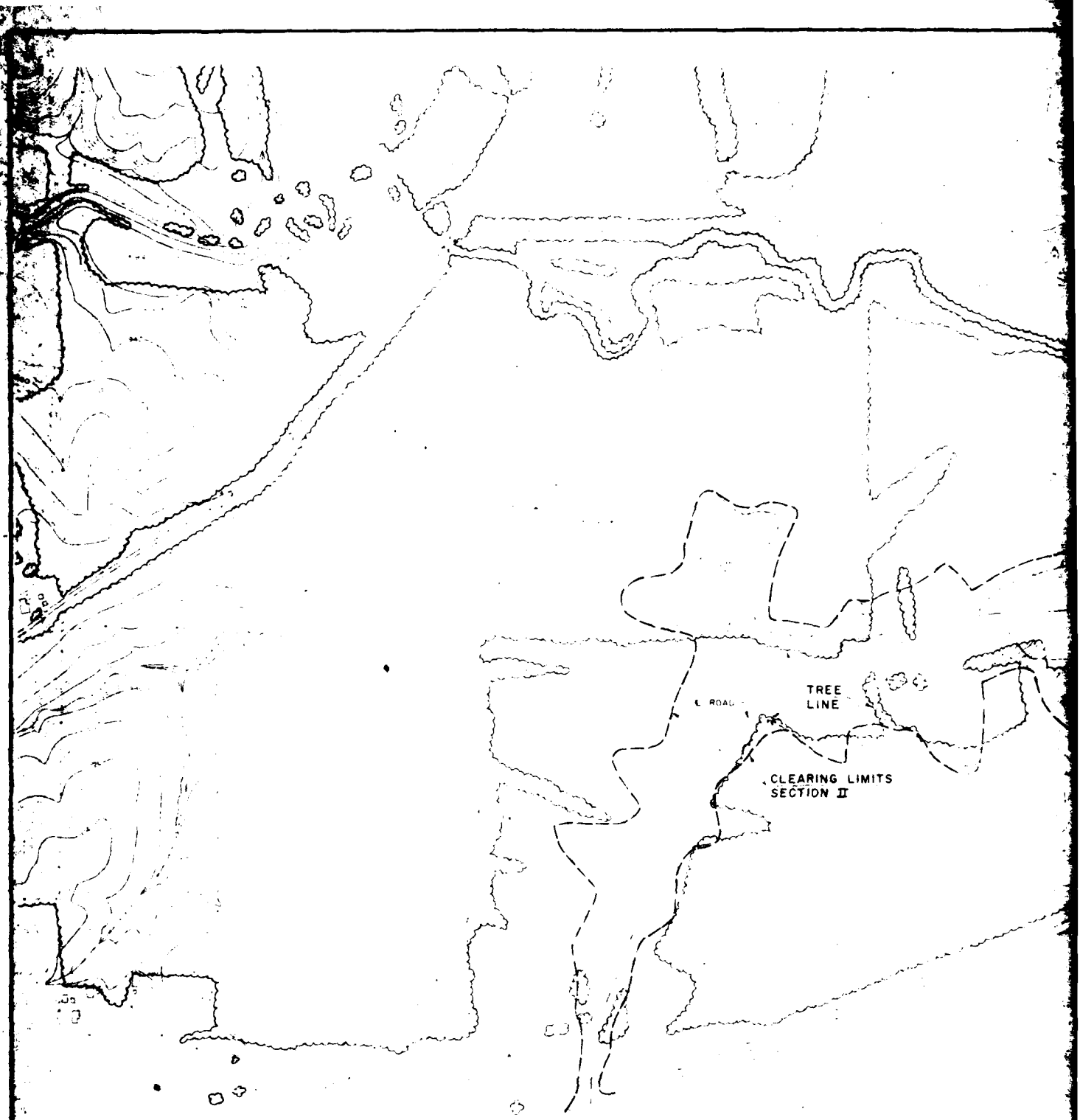
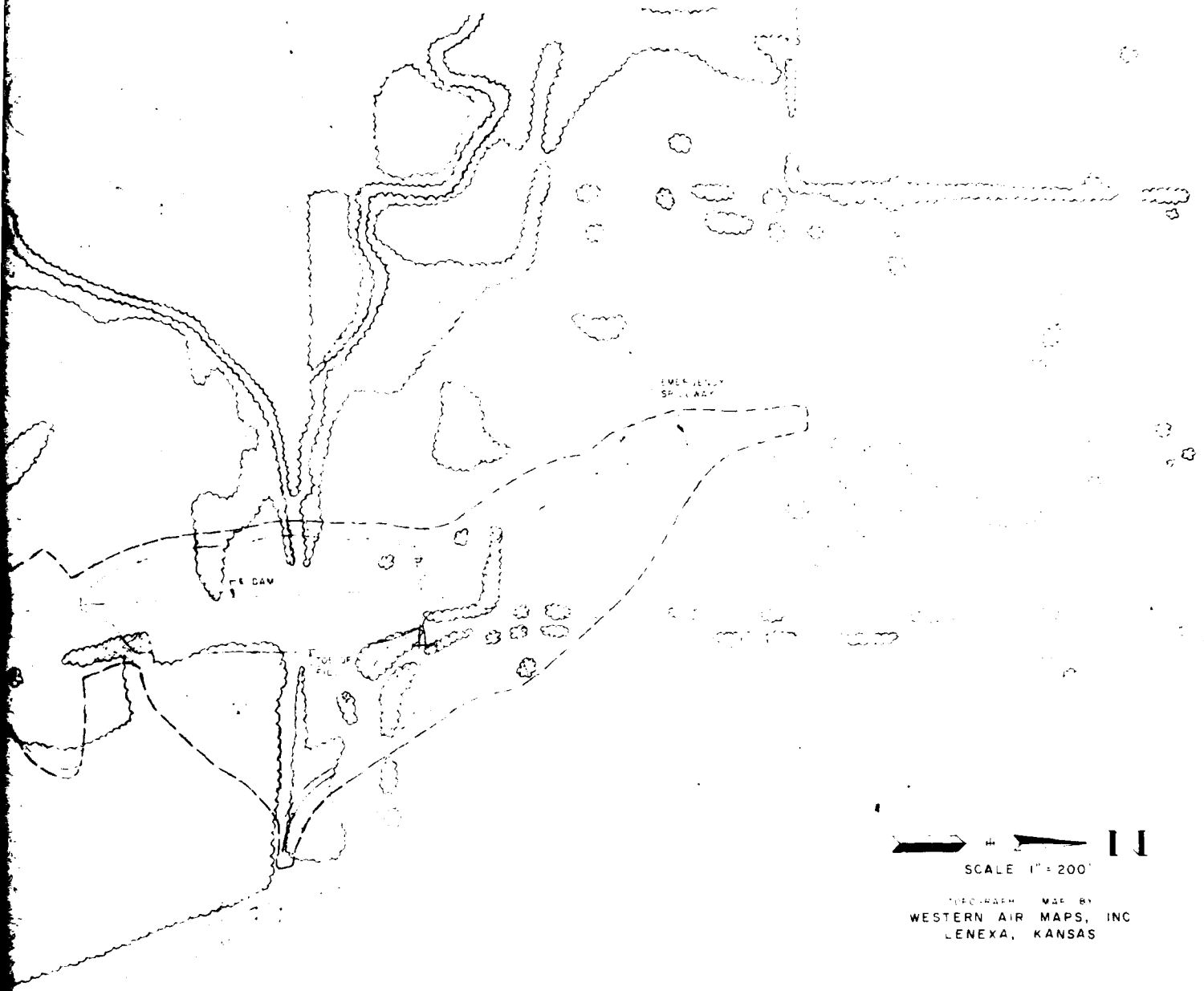


PLATE C-2


TREE
LINE
CLEARING LIMITS
SECTION II



SCALE 1" = 200'

TOPOGRAPH MAP BY
WESTERN AIR MAPS, INC
LENEXA, KANSAS

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

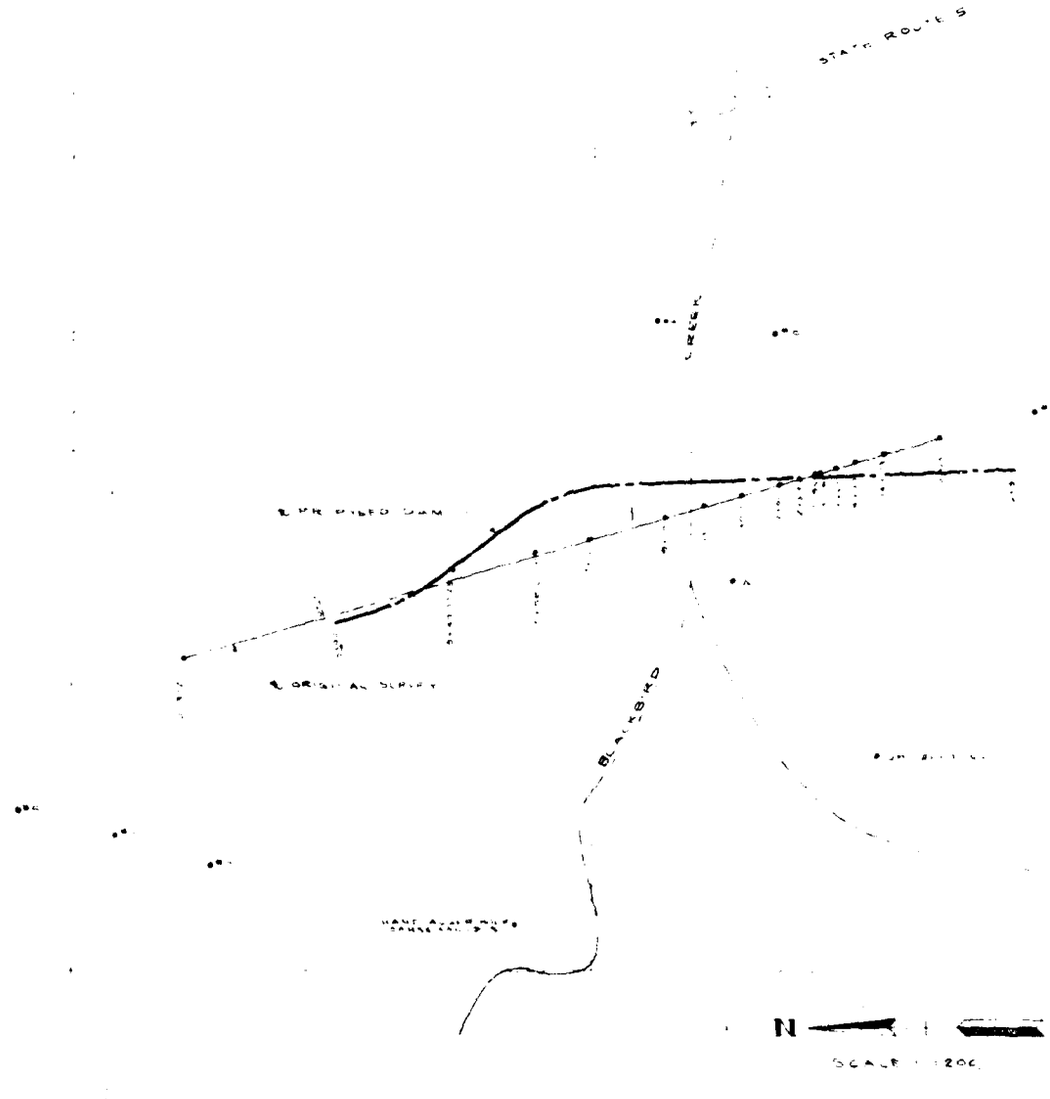
SITE PLAN - CLEARING
SECTION II

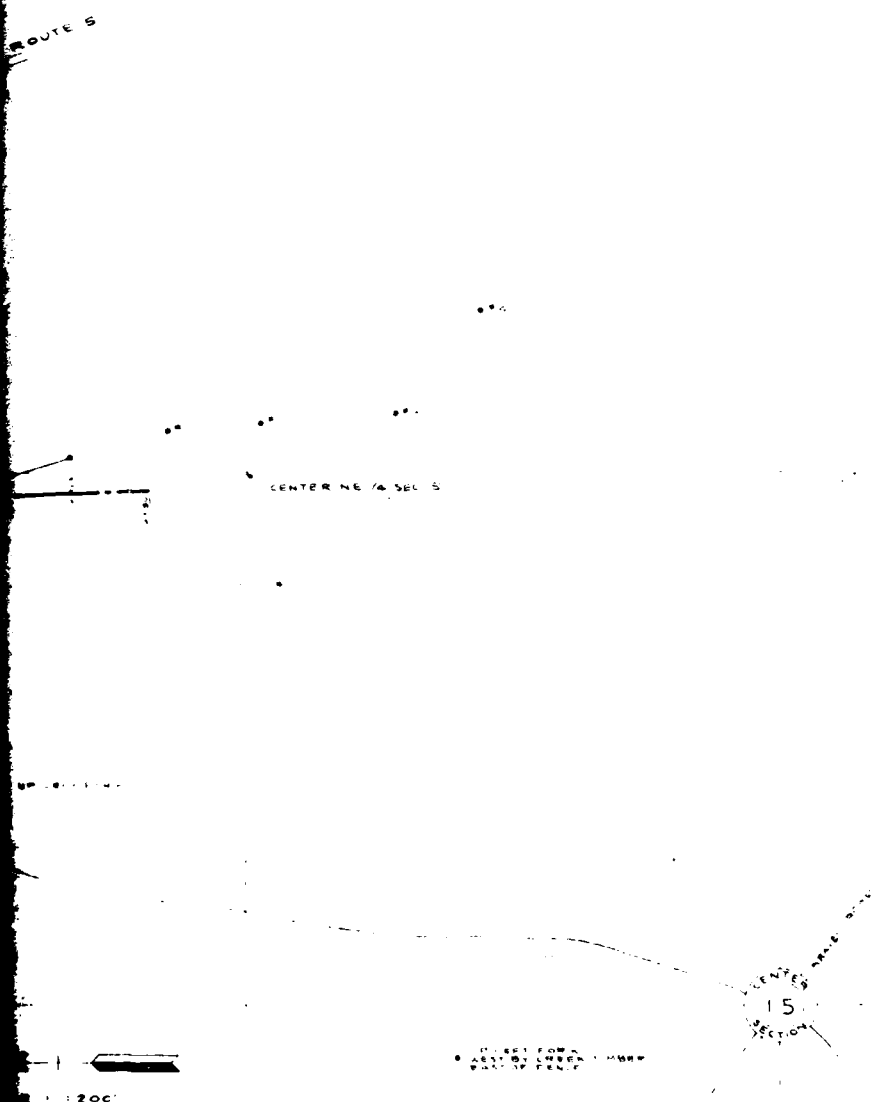
W H KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
617 BROADWAY QUINCY, ILLINOIS

MARCH 196

SHEET NO 4 OF 8 SHEETS

PLATE C-5

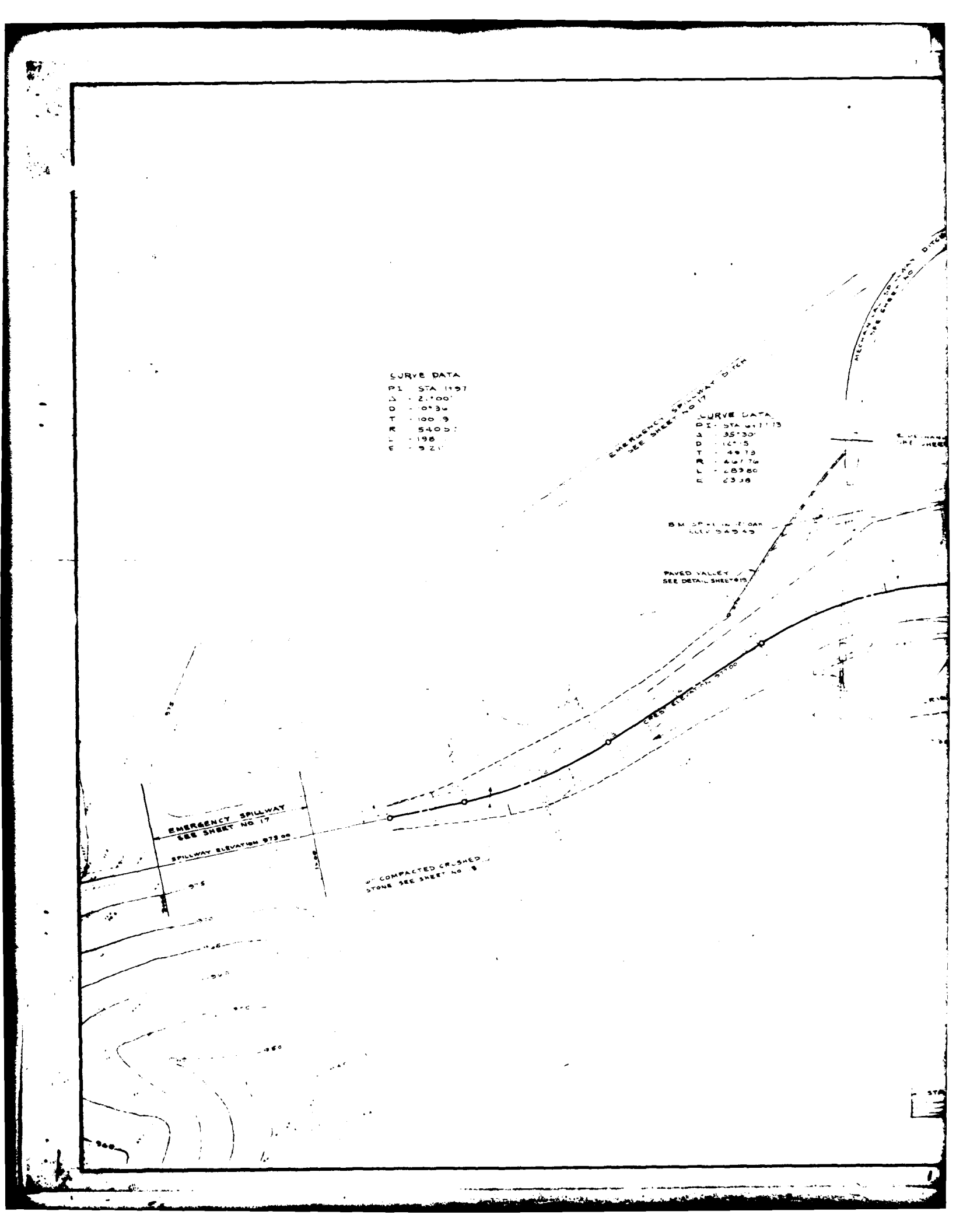

STATE ROUTE 5
CREEK
BLACKBIRD
N

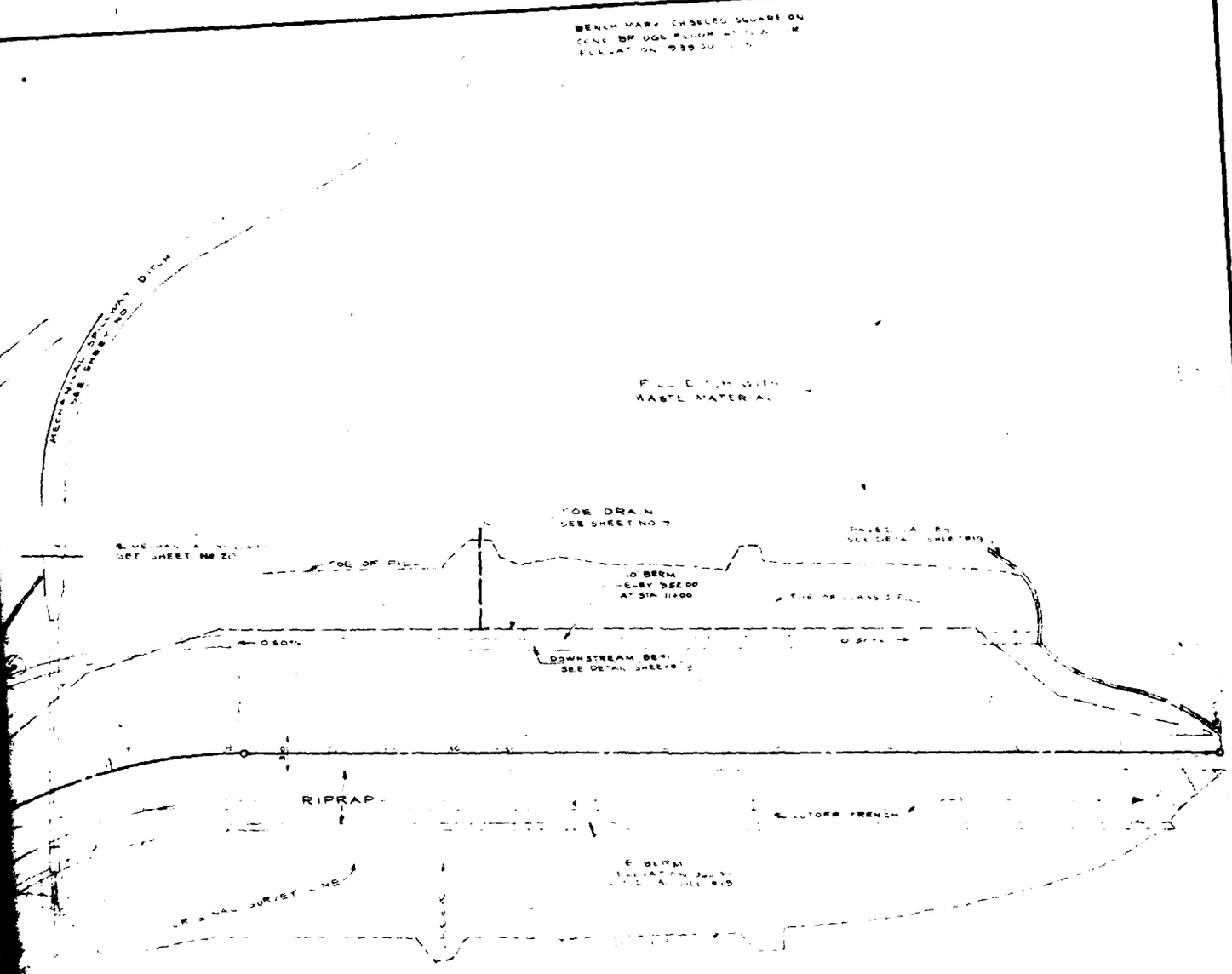


SEE SPECIFICATIONS FOR SOIL PROFILE
A COMPLETE LOG OF SOIL BORINGS IS AVAILABLE AT THE UNIONVILLE CITY HALL OR AT THE OFFICE OF W. H. KLINGNER AND ASSOCIATES, CONSULTING ENGINEERS 417 BROADWAY QUINCY, ILLINOIS

SOIL BORING LOCATION MAP			
PUTNAM COUNTY LAKE ASSOCIATION, INC. UNIONVILLE, MISSOURI			
W. H. KLINGNER AND ASSOCIATES, ENGINEERS 417 BROADWAY QUINCY, ILLINOIS			
DATE	DRAWN	CHECKED	SHEET NO 8 OF 28 SHEETS
OCT 1964	A B H	[illegible]	

PLATE C-4


CURVE DATA
PI STA 1+97
Δ = 2°00'
D = 0°36
T = 100.9
R = 5405
L = 198
E = 9.21
CURVE DATA
PI = STA 0+71.13
Δ = 35°30'
D = 12°15
T = 49.73
R = 467.76
L = 289.80
E = 23.38
EMERGENCY SPILLWAY DITCH
SEE SHEET NO 17
EMERGENCY SPILLWAY
SEE SHEET NO 17
SPILLWAY ELEVATION 973.00
PAVED VALLEY
SEE DETAIL SHEET NO 19
COMPACTED CRUSHED
STONE SEE SHEET NO



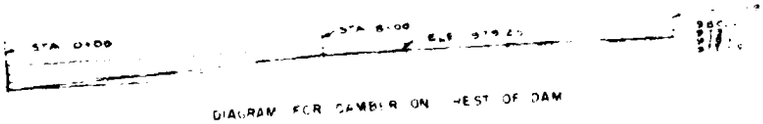


DIAGRAM FOR CAMBER ON WEST OF DAM

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

GENERAL PLAN OF DAM SITE

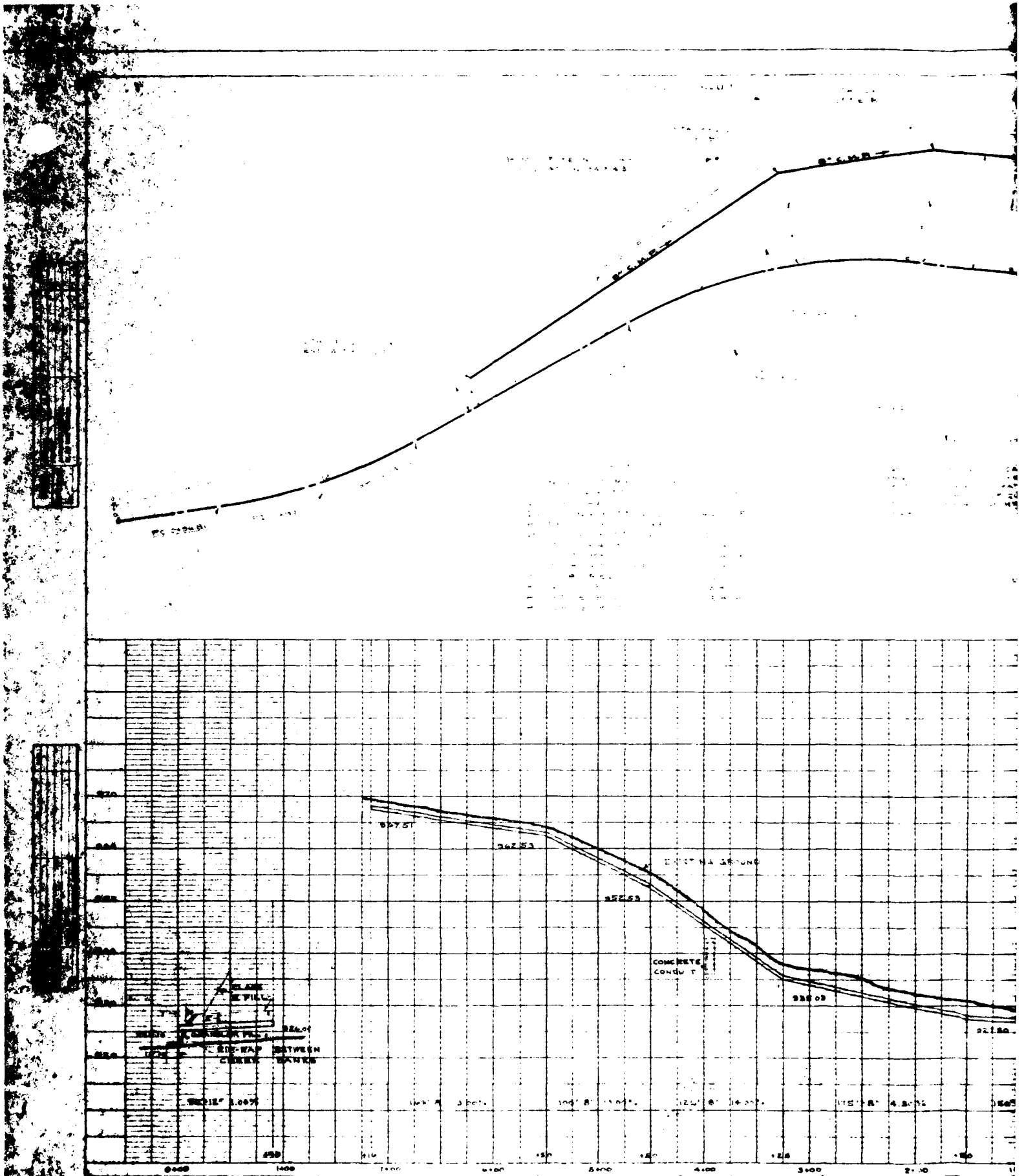
W H KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
611 BROADWAY QUINCY, ILLINOIS

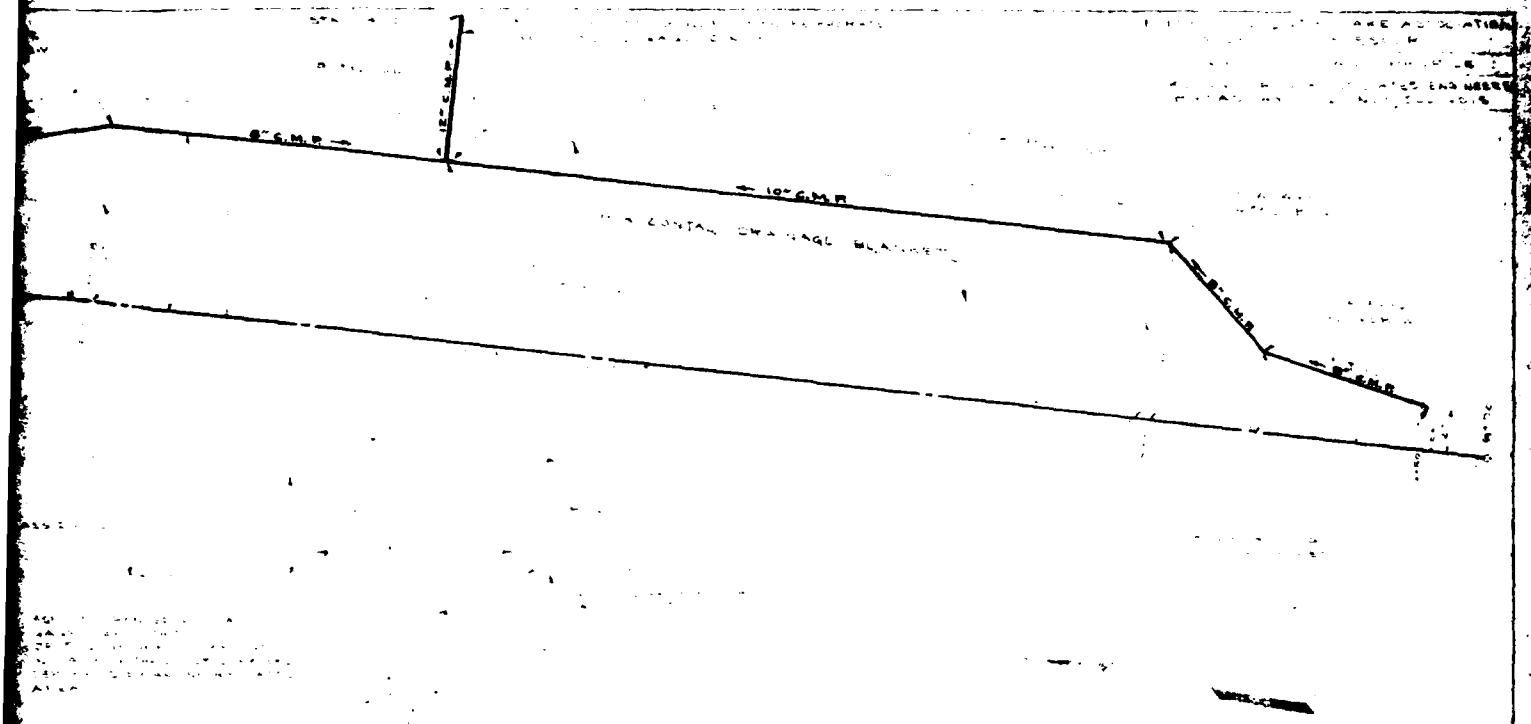
DRAWN	CHECKED	DATE
A B HARMAN	E CHURNESS	MARCH 1965

SHEET NO 6 OF 28 SHEETS

PLATE C-6

12


927.51
926.53
925.63
938.03
CONCRETE
CONDUIT
EARTH FILL
ROCK FILL
RIP-RAP BETWEEN
CRIBBS
BANKS



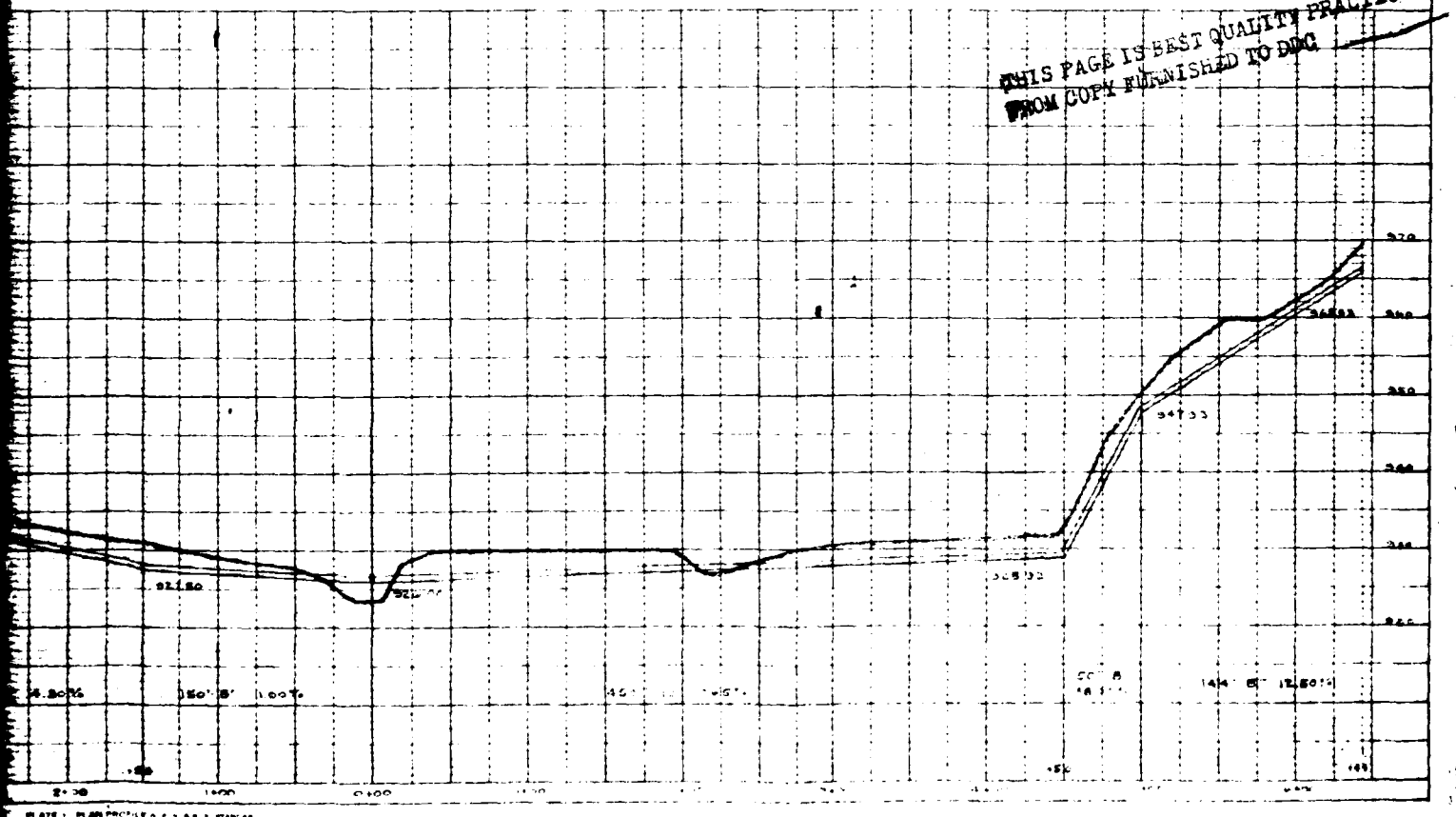
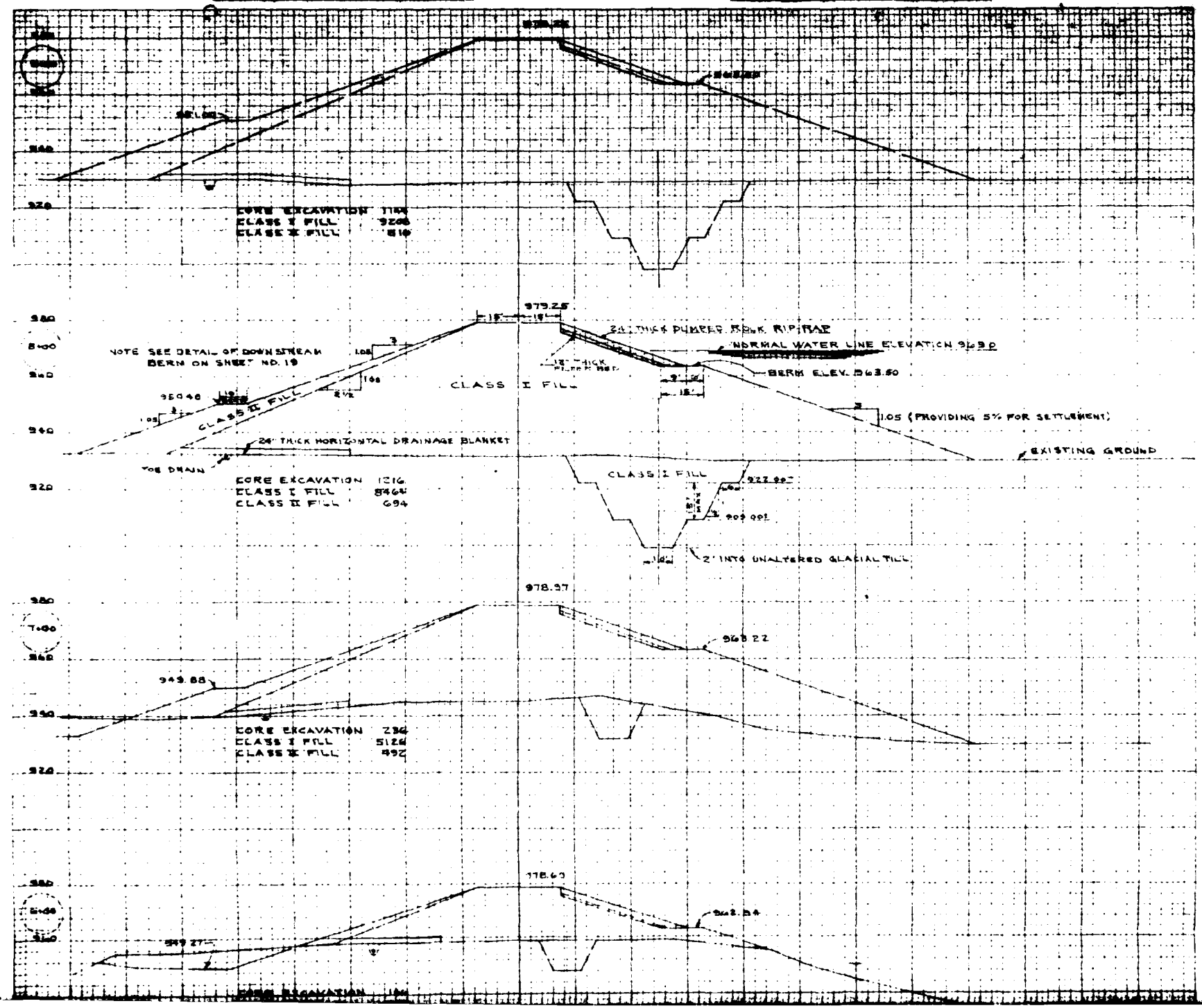


PLATE C-6


CORE EXCAVATION 1164
CLASS I FILL 9268
CLASS II FILL 810
NOTE SEE DETAIL OF DOWNSTREAM BERM ON SHEET NO. 19
CLASS II FILL
CLASS I FILL
24" THICK HORIZONTAL DRAINAGE BLANKET
TOE DRAIN
NORMAL WATER LINE ELEVATION 969.0
BERM ELEV. 963.50
1.05 (PROVIDING 5% FOR SETTLEMENT)
EXISTING GROUND
CORE EXCAVATION 1216
CLASS I FILL 8464
CLASS II FILL 694
CLASS I FILL
2' INTO UNALTERED GLACIAL TILL
CORE EXCAVATION 236
CLASS I FILL 5126
CLASS II FILL 492

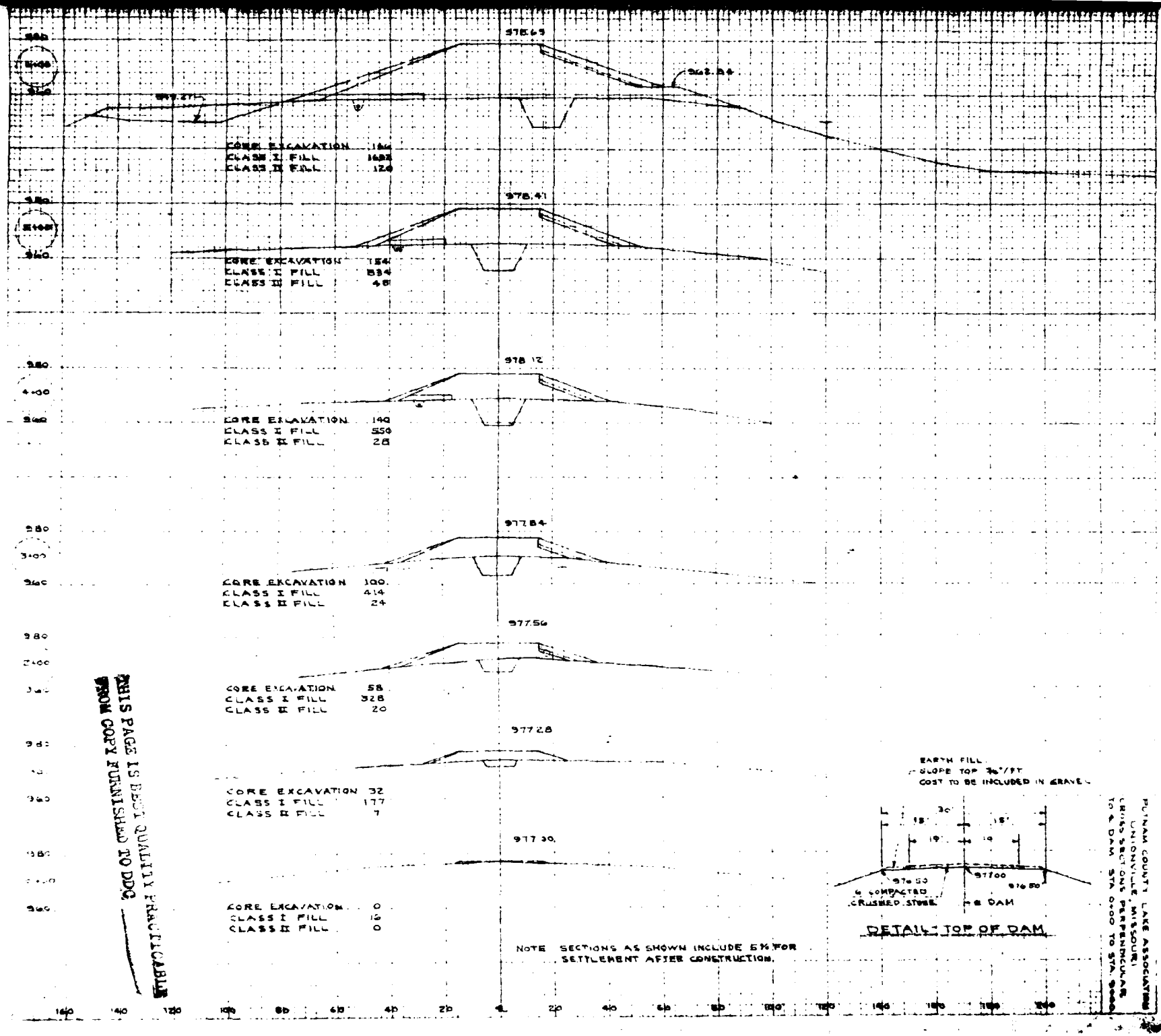
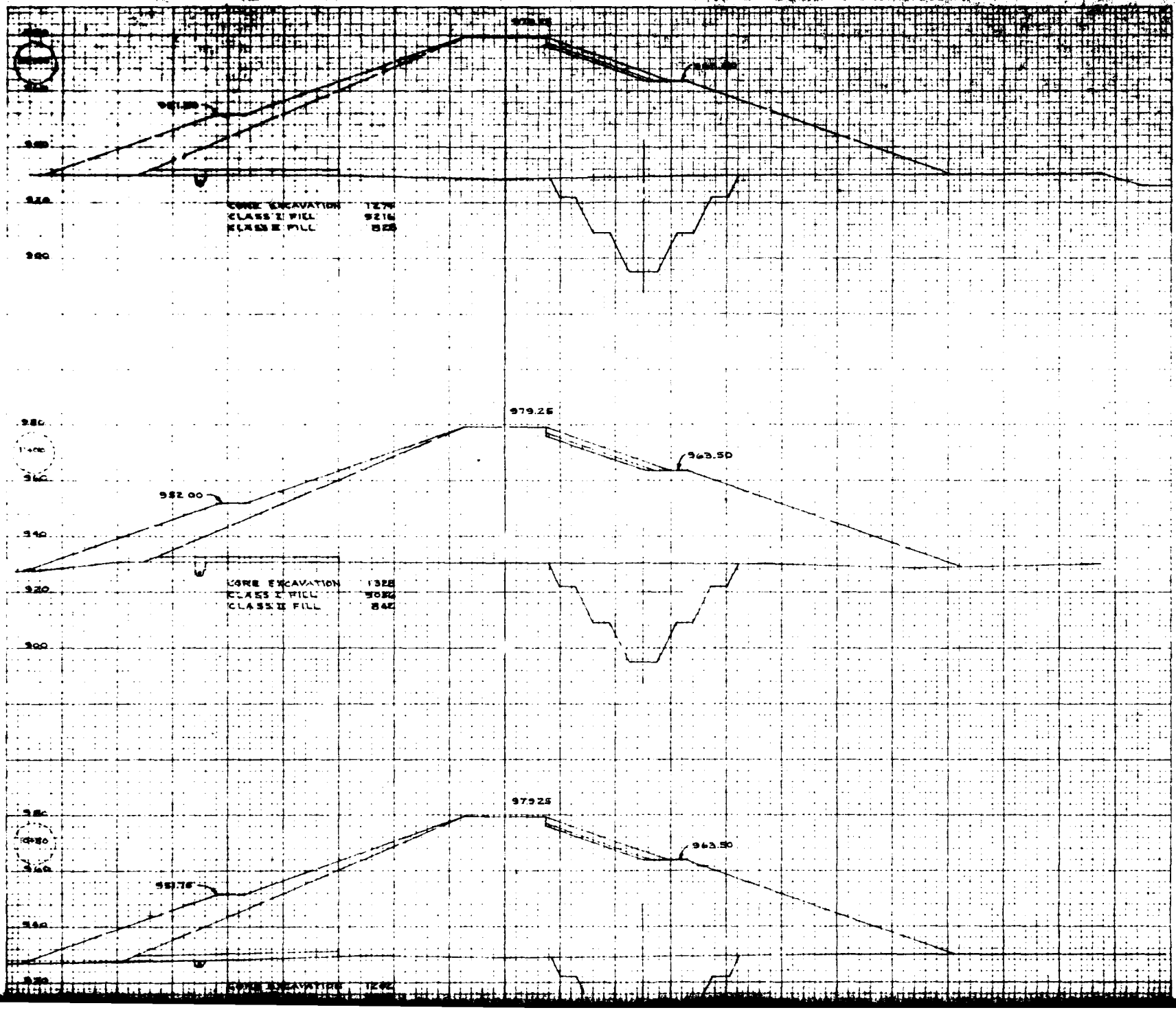


PLATE C-7


CORE EXCAVATION 1278
CLASS I FILL 9216
CLASS II FILL 826
979.25
963.50
952.00
CORE EXCAVATION 1328
CLASS I FILL 9080
CLASS II FILL 840
979.25
963.50
951.75

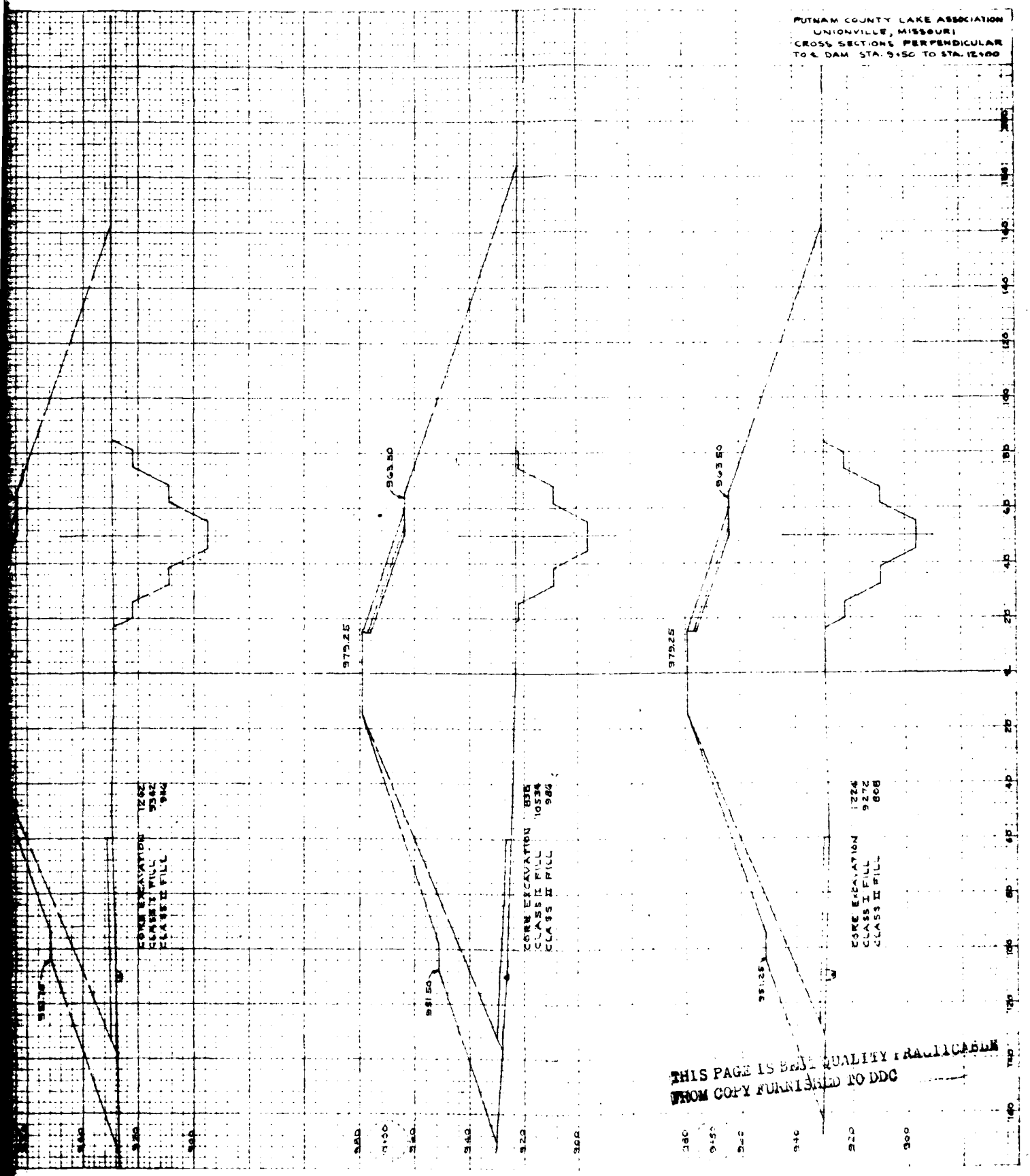
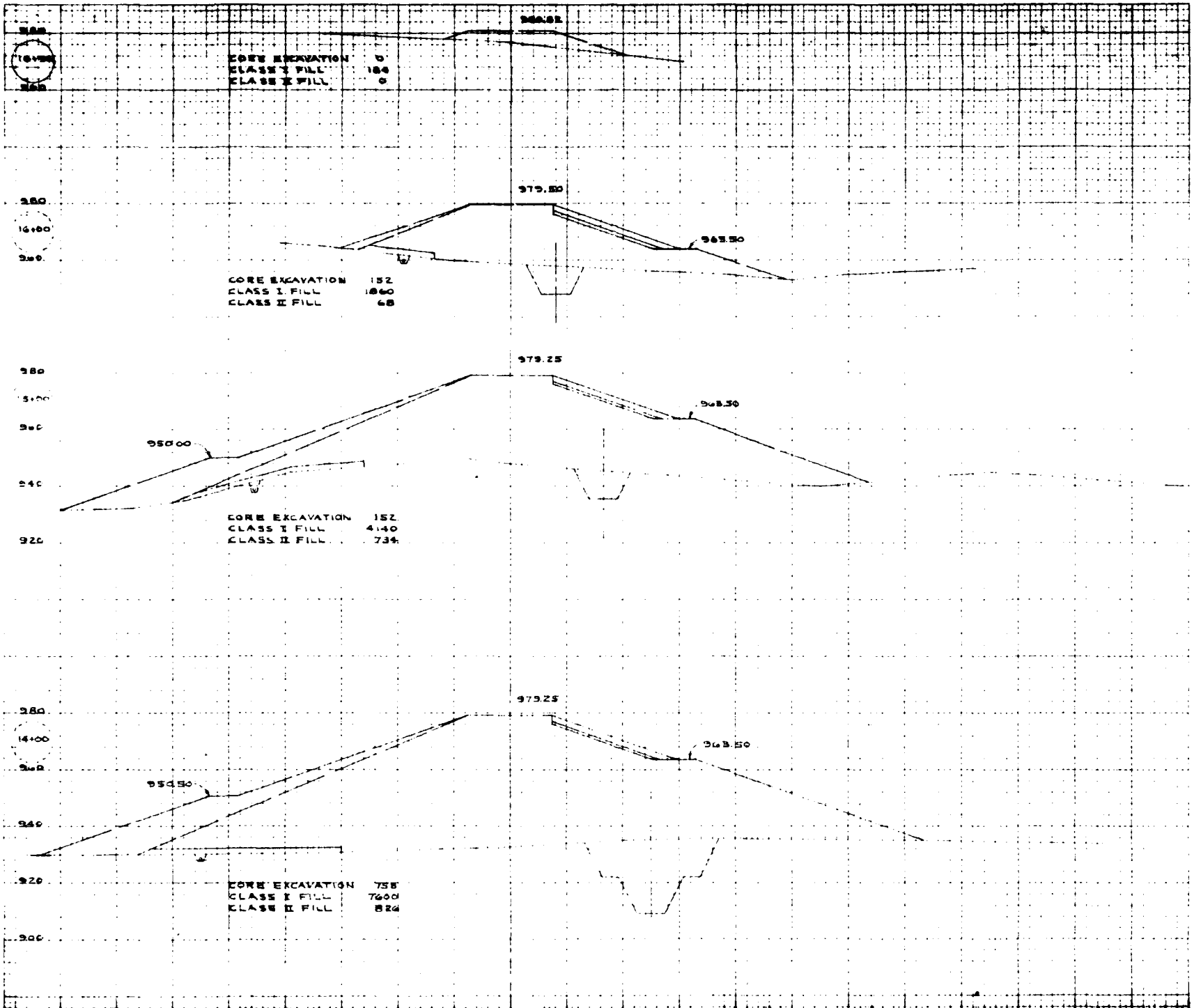


PLATE C-8

ORIGINAL SURVEY	BY	DATE
NOTE BOOK NO.		

FINAL SURVEY	BY	DATE
NOTE BOOK NO.		



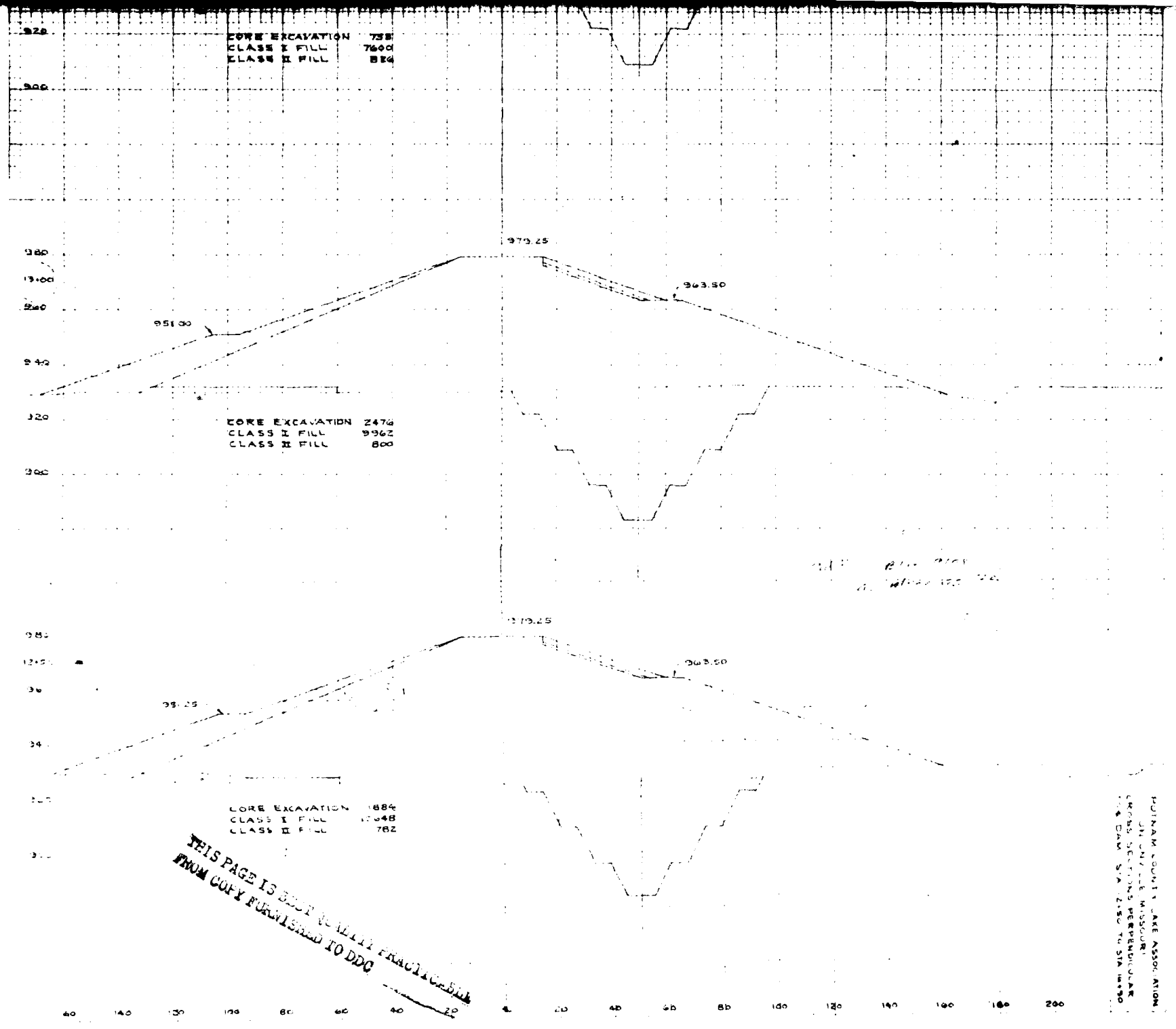
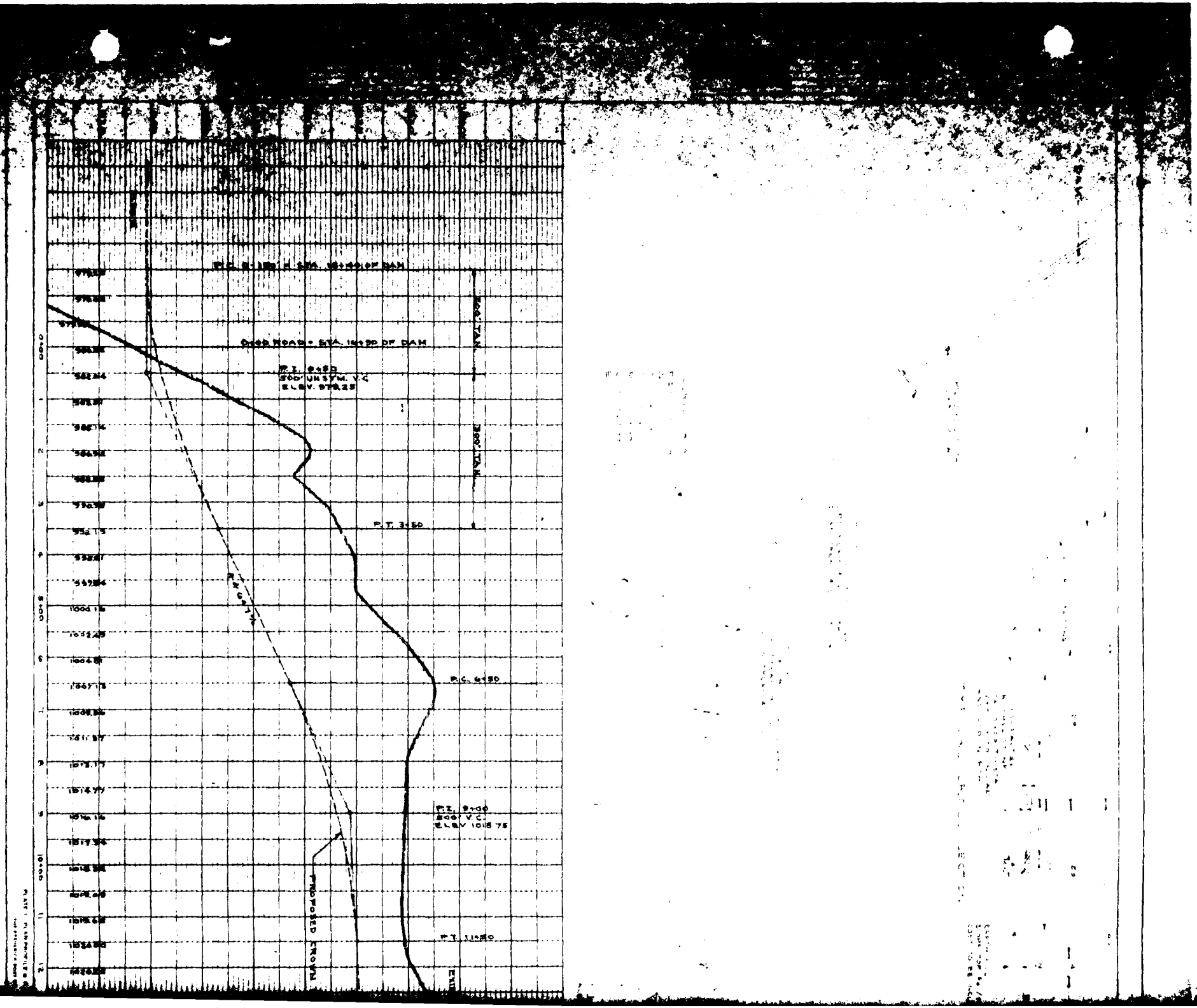


PLATE C-9


P.C. 0+50
P.I. 0+50
300' UNSYM. V.C.
ELEV. 979.25
P.T. 3+50
P.C. 6+50
P.I. 9+00
300' V.C.
ELEV. 1018.75
P.T. 11+50
PROPOSED GROWN
EXIS

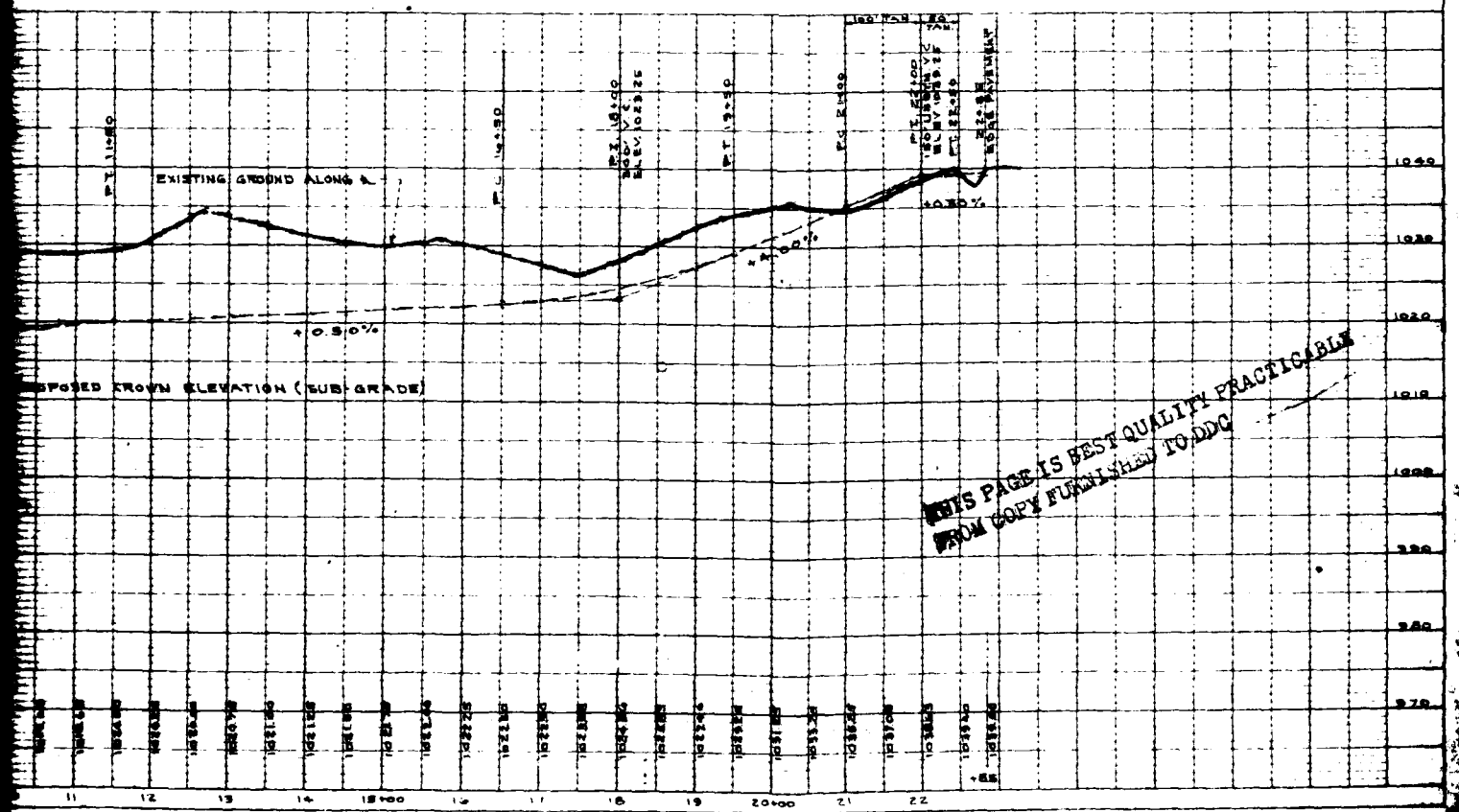
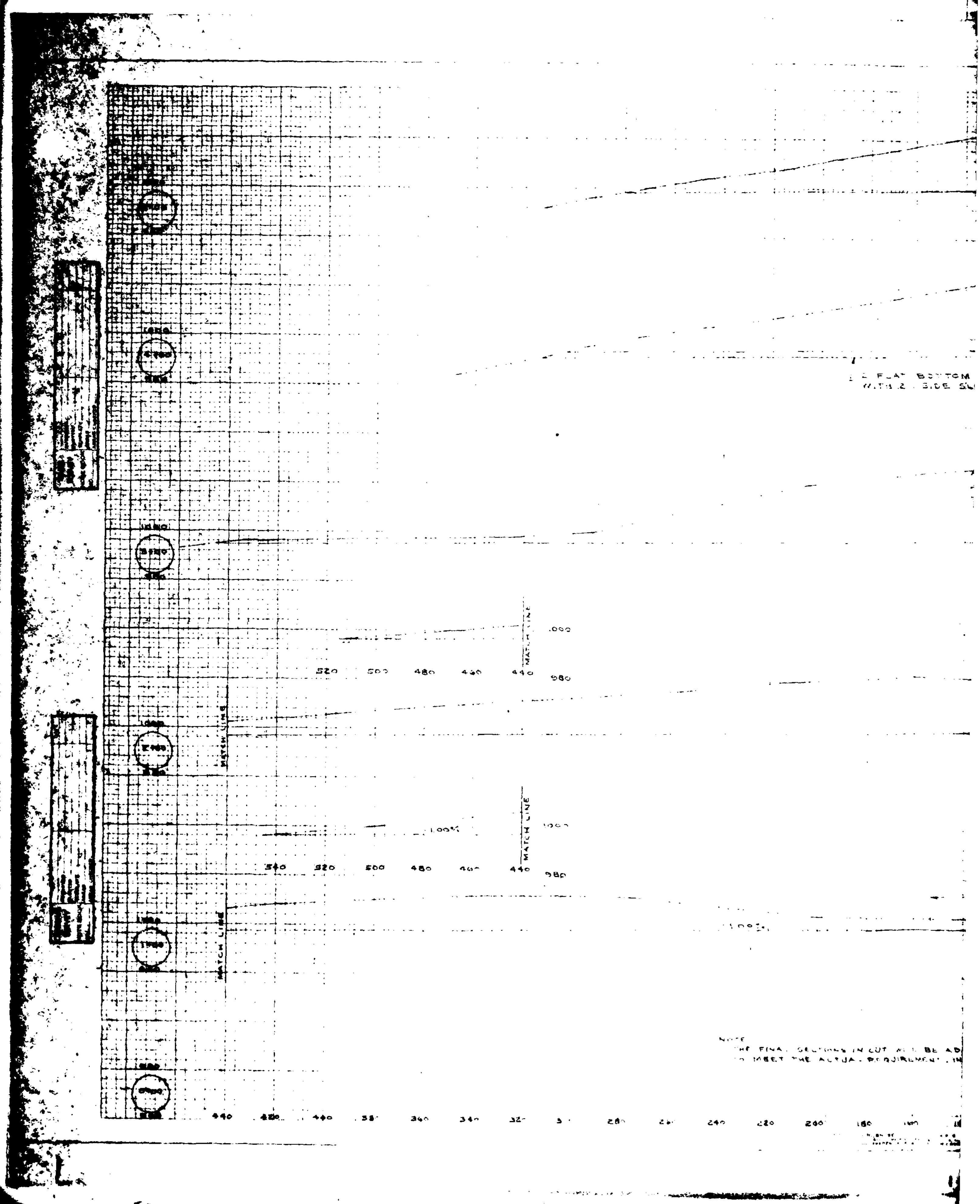
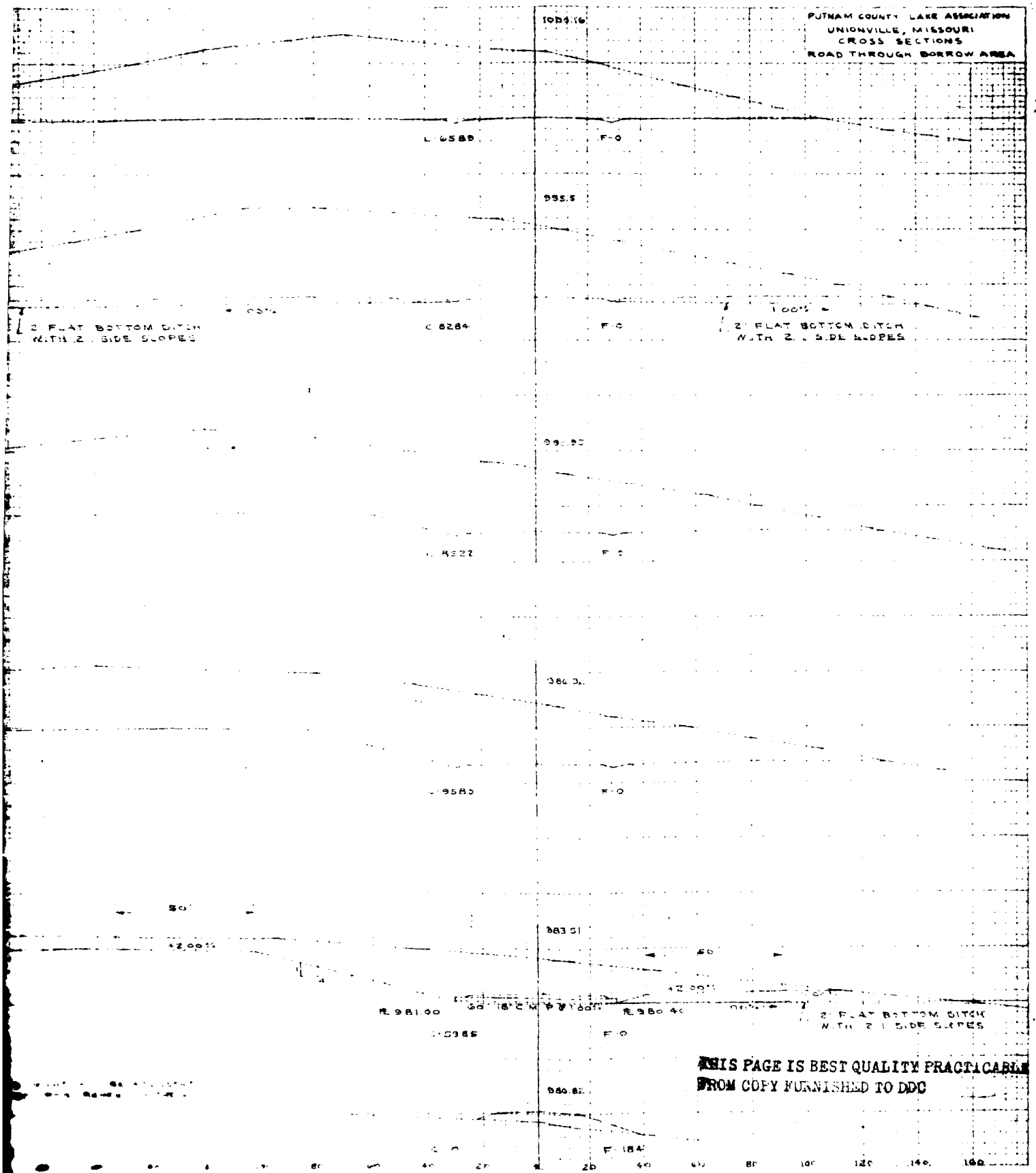


PLATE 1 PLAN PROFILE 0 × 4 × 8 × 5 STANDARD
THE FREDERICK POST CO. CHICAGO

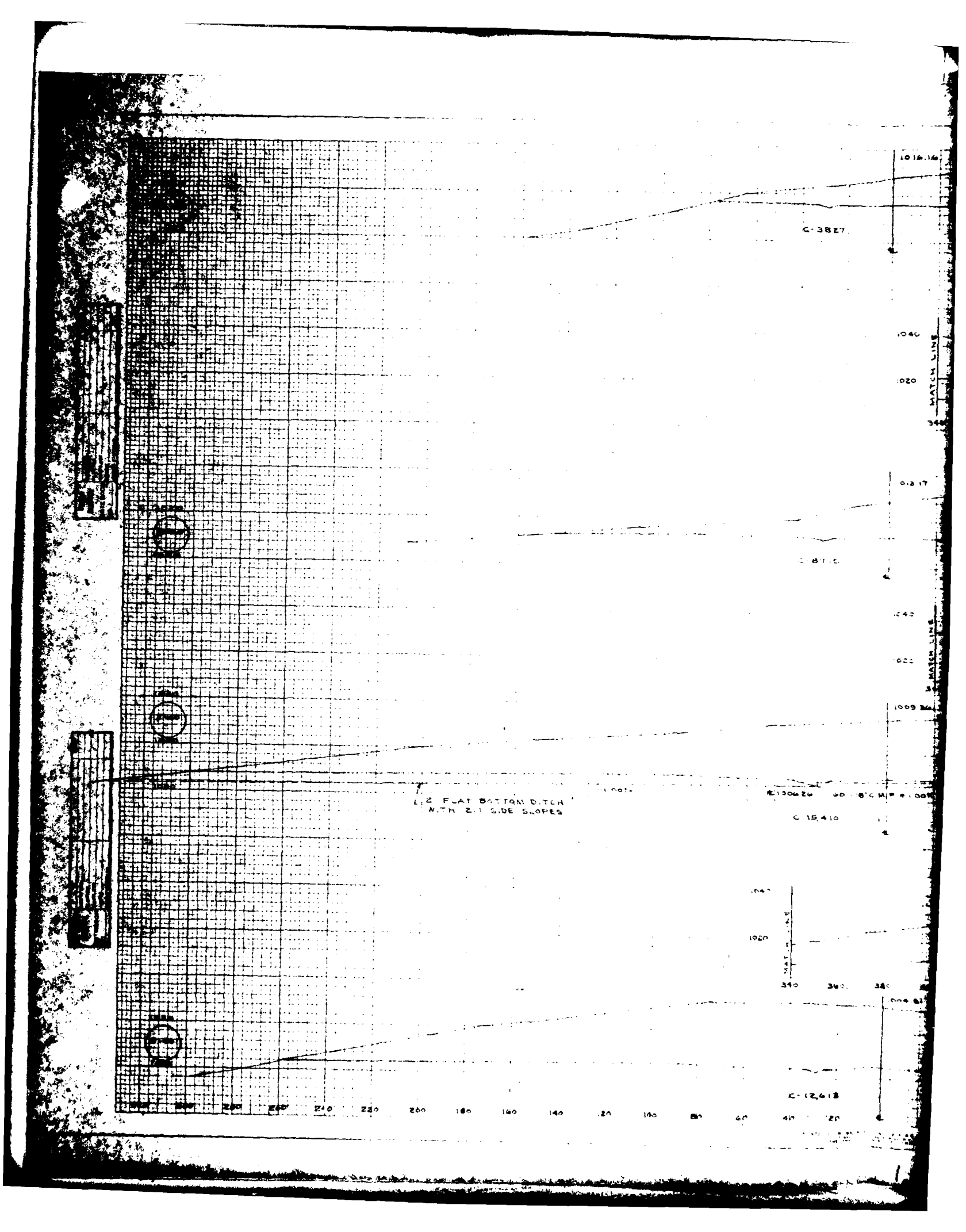

MATCH LINE
.000
520
500
480
440
980
1.00%
540
NOTE

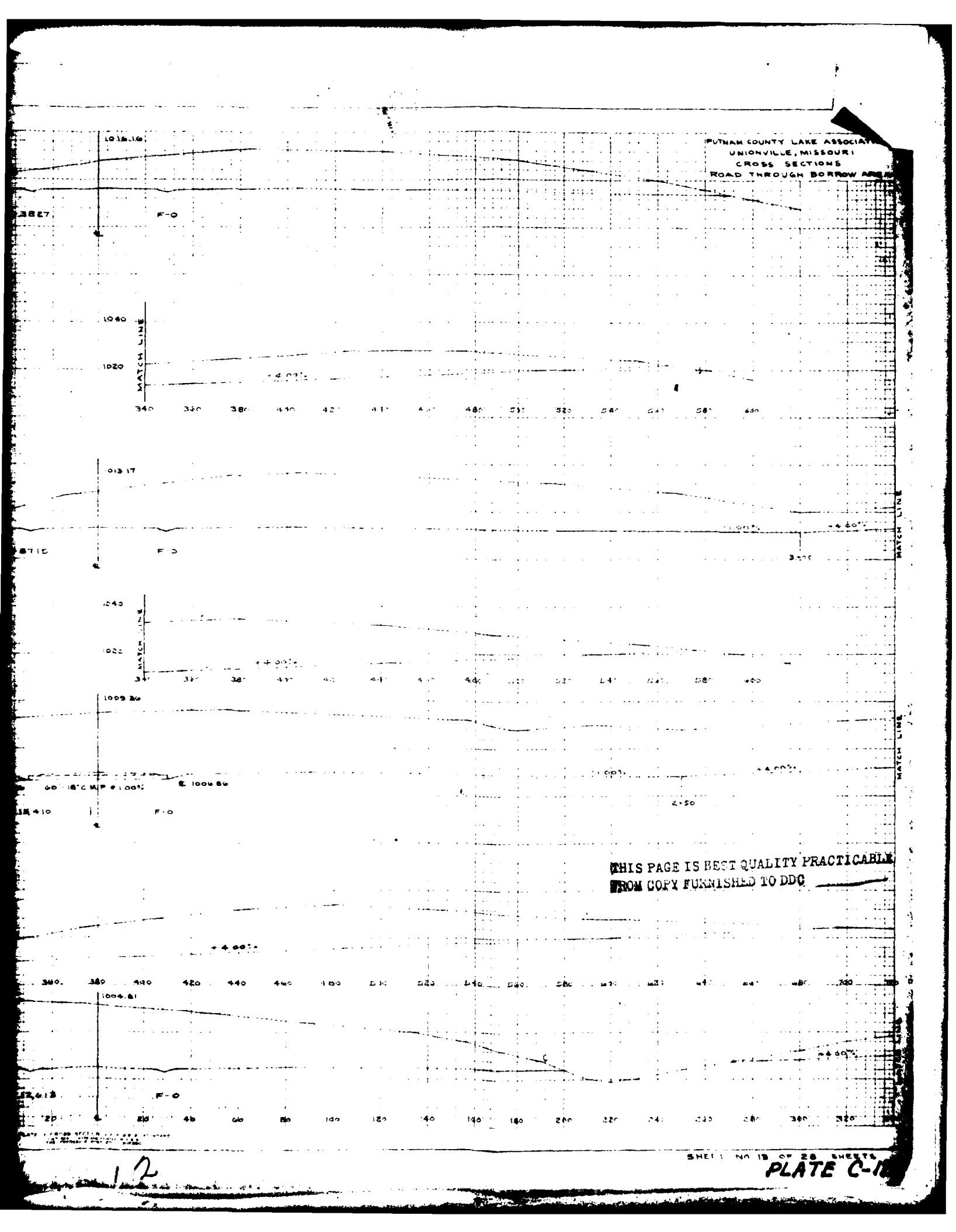
PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI
CROSS SECTIONS
ROAD THROUGH BORROW AREA

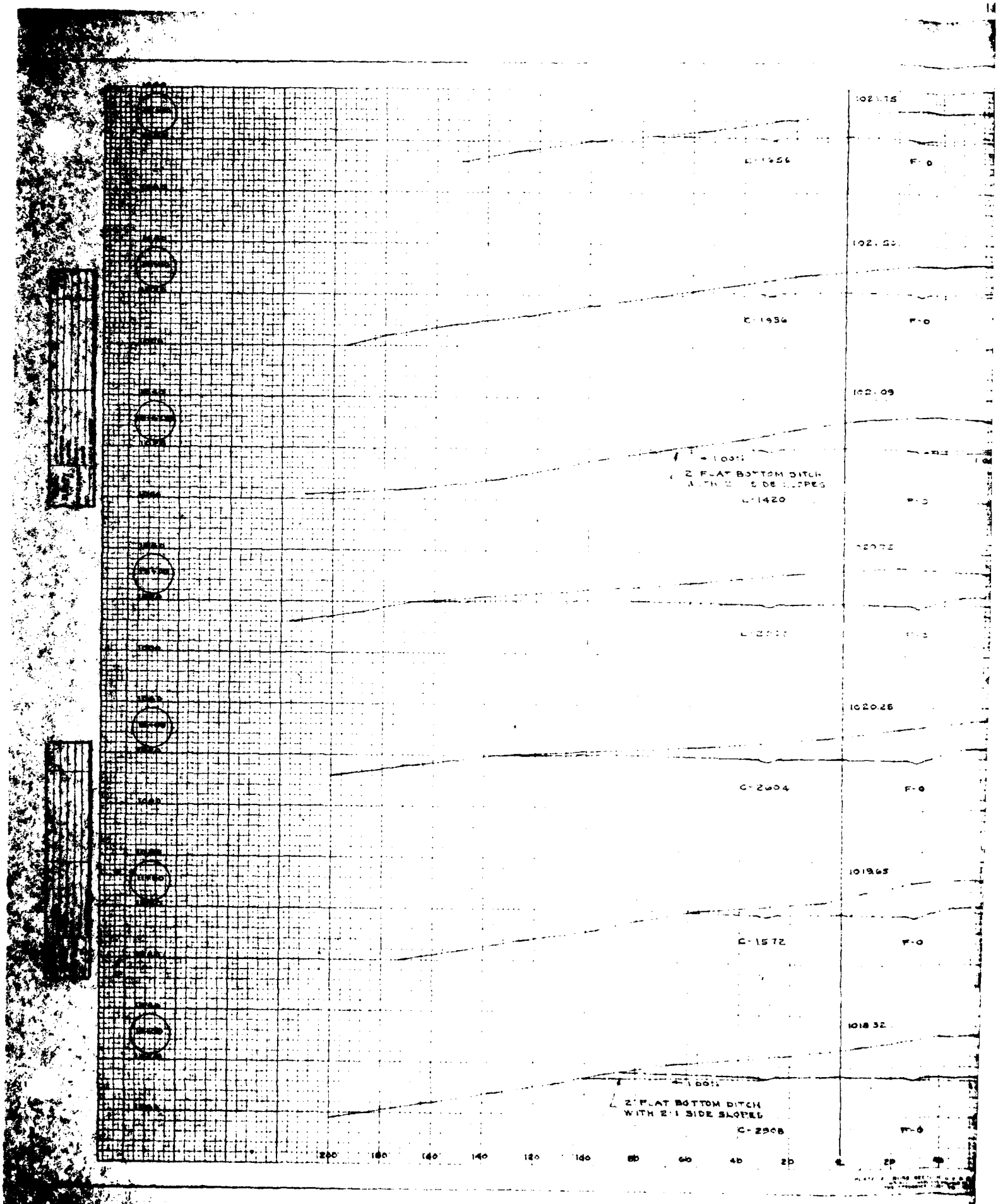


SHEET 12 OF 28 SHEETS

PLATE C-11


L.2 FLAT BOTTOM DITCH
WITH 2:1 SIDE SLOPES
C-3827
C-8116
C 15,410
C-12,618
MATCH LINE
MATCH LINE
1040
1020
1000
340
360
380
240
220
200
180
160
140
120
100
80
60
40
20




102.15
C-1456
F-0
102.52
C-1936
F-0
102.09
2' FLAT BOTTOM DITCH
C-1420
1020.28
C-2004
F-0
1019.65
C-1572
F-0
1018.32
2' FLAT BOTTOM DITCH
WITH 2:1 SIDE SLOPES
C-2908
F-0
200
180
160
140
120
100
80
60
40
20
0
20

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI
CROSS SECTIONS
ROAD THROUGH BORROW AREA

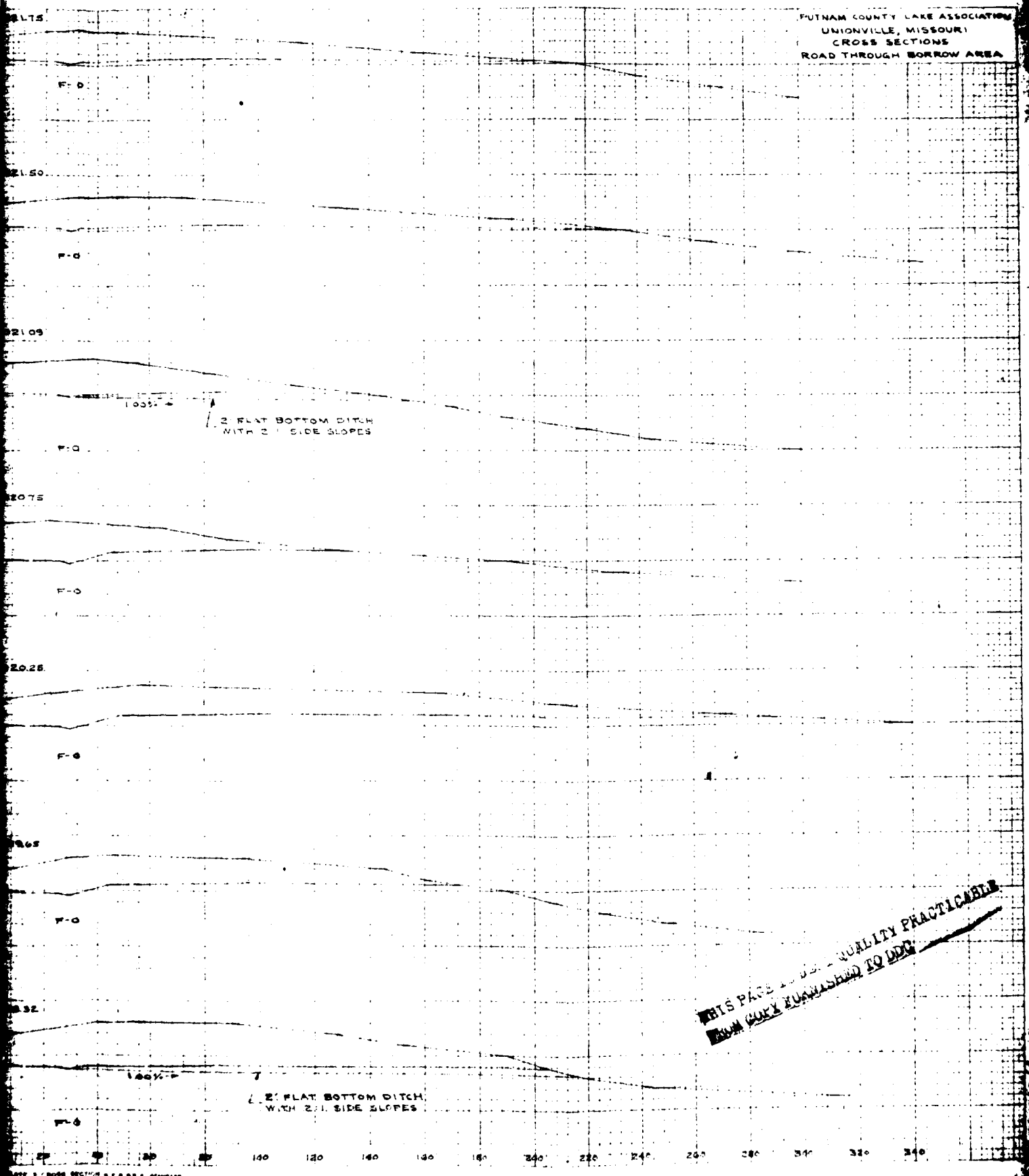
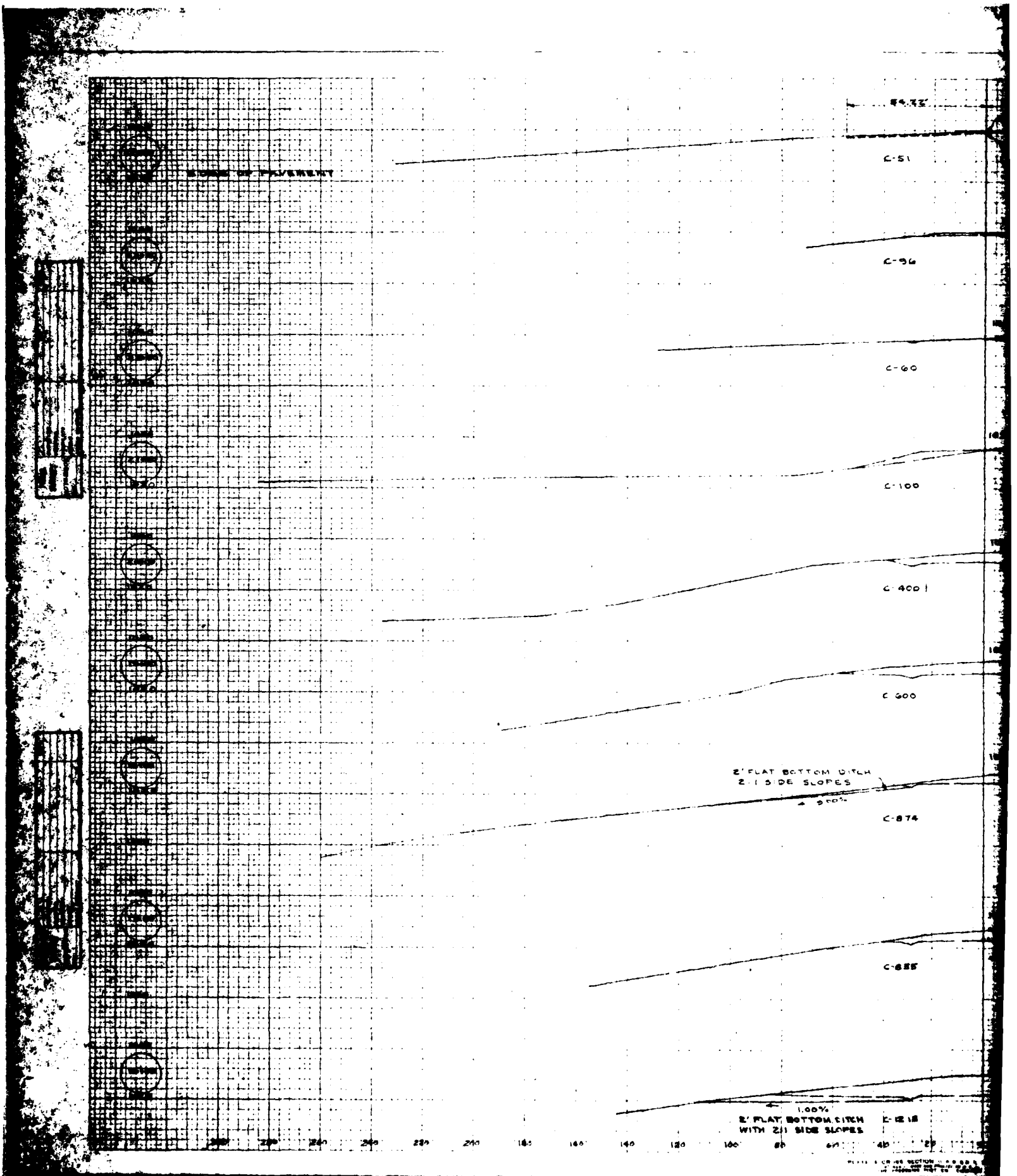
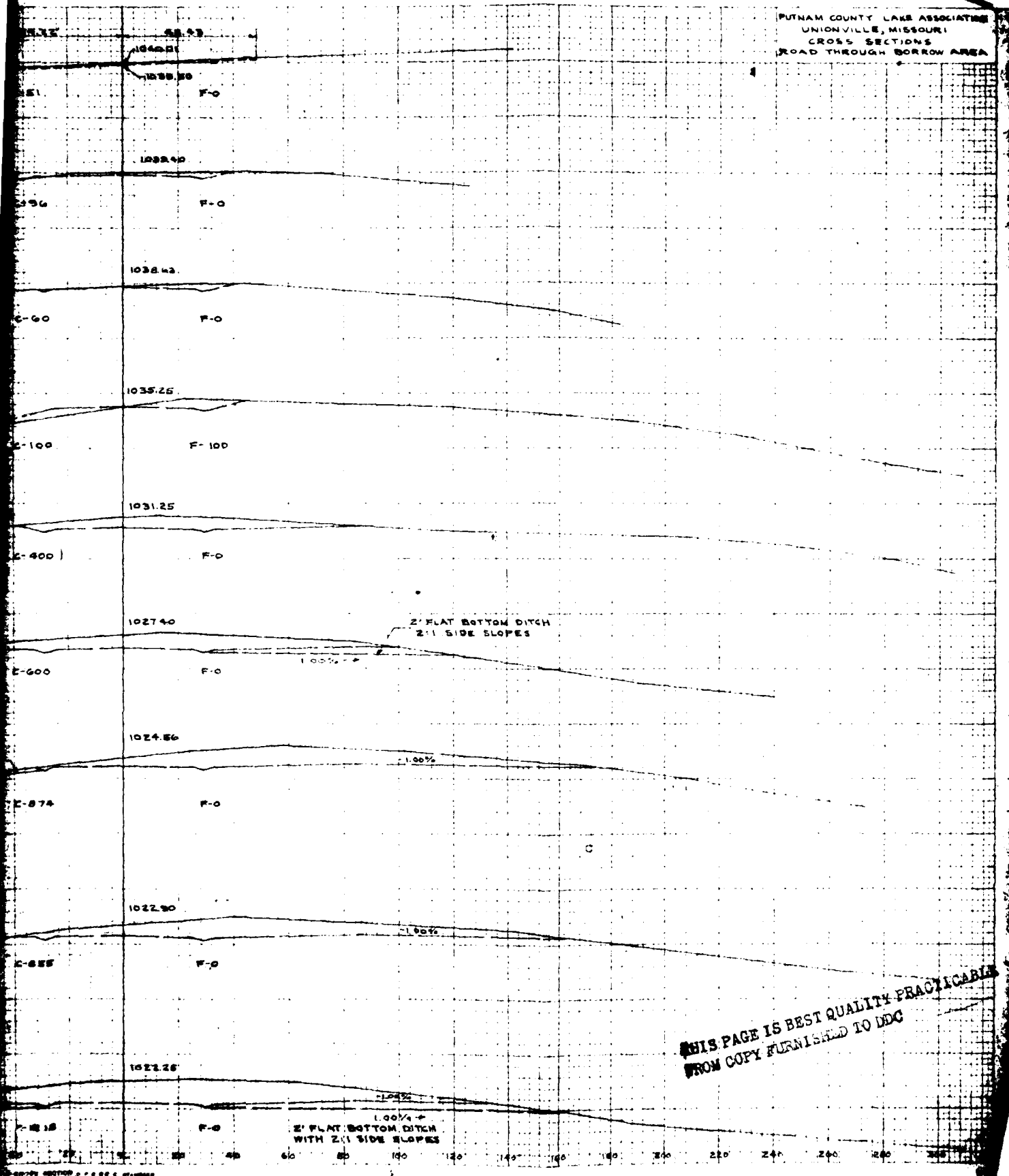


PLATE C-13

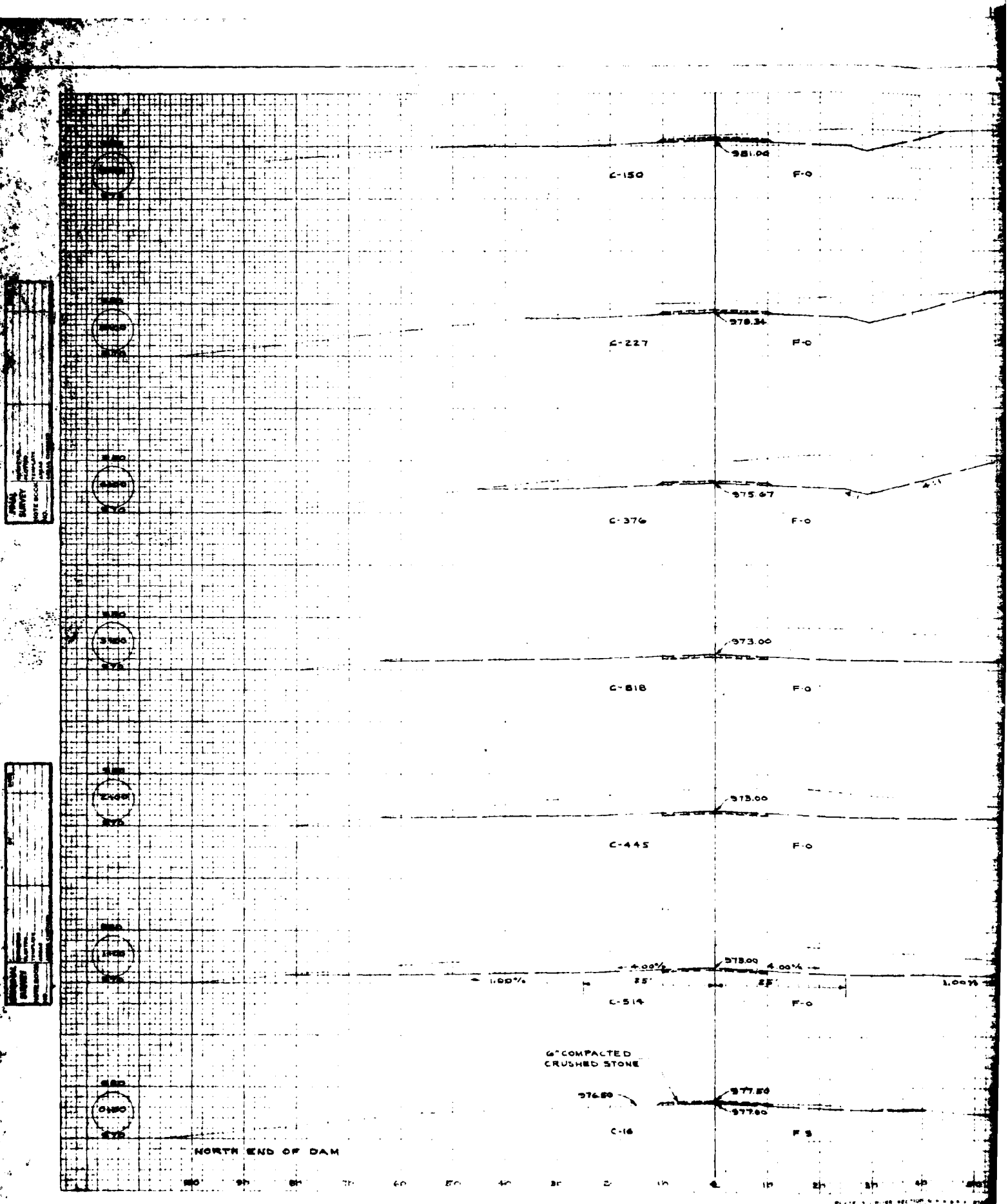

EDGE OF PAVEMENT
C-51
C-96
C-60
C-100
C-400 I
C-600
2' FLAT BOTTOM DITCH
2:1 SIDE SLOPES
C-874
C-885
1.00%
2' FLAT BOTTOM DITCH
WITH 2:1 SIDE SLOPES
C-12.18

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI
CROSS SECTIONS
ROAD THROUGH BORROW AREA

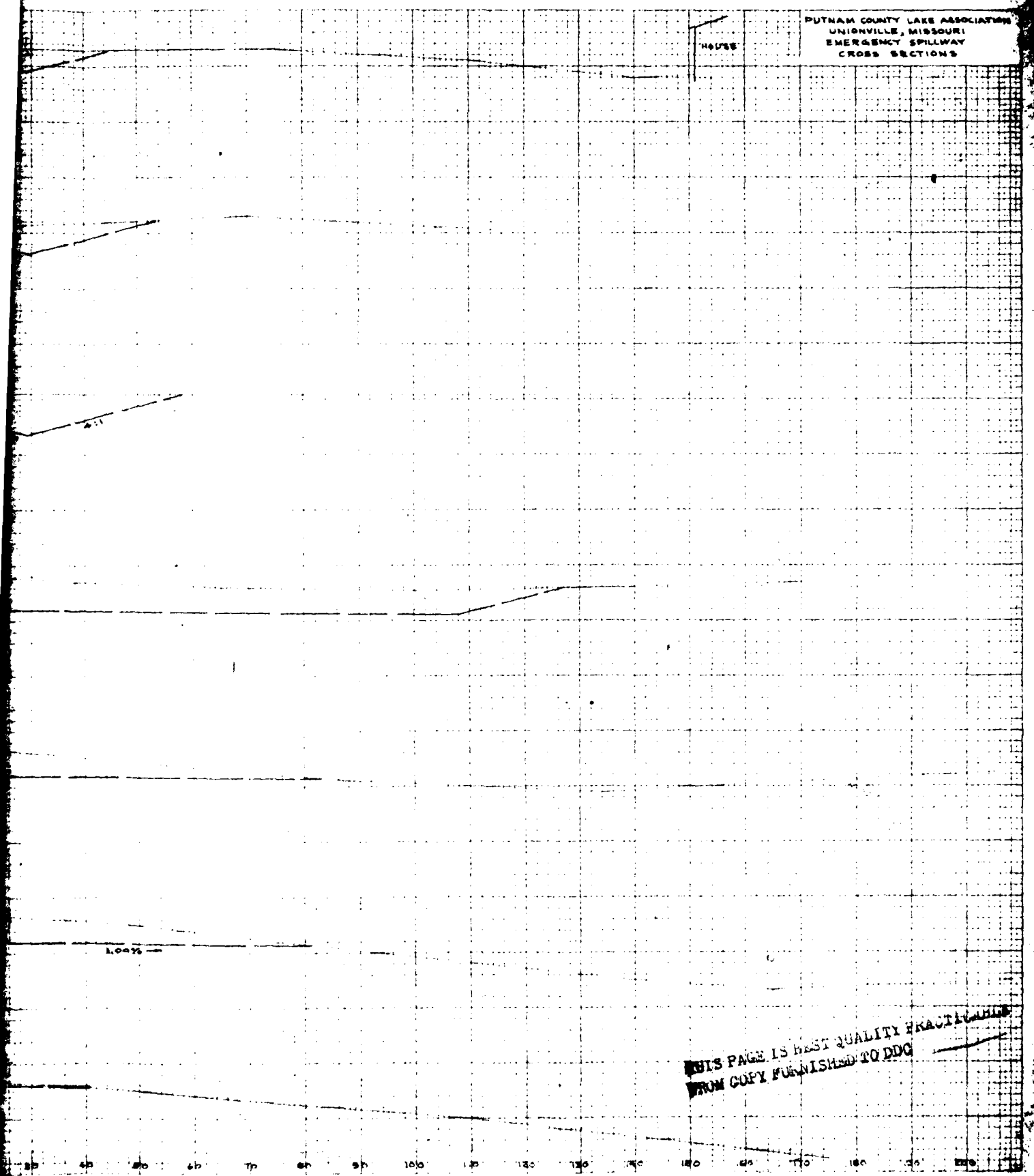


SHEET NO 18 OF 28 SHEETS

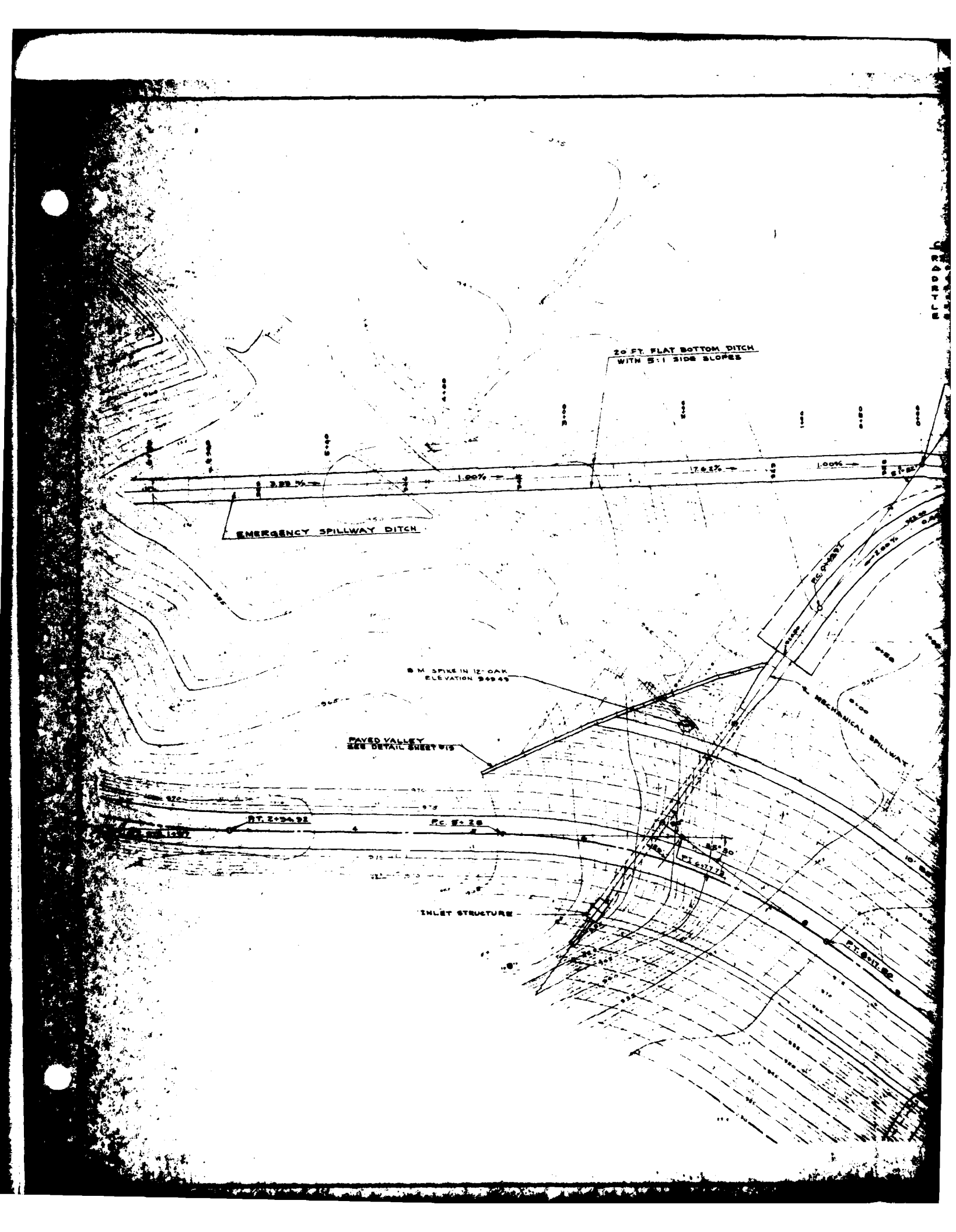
PLATE C-44

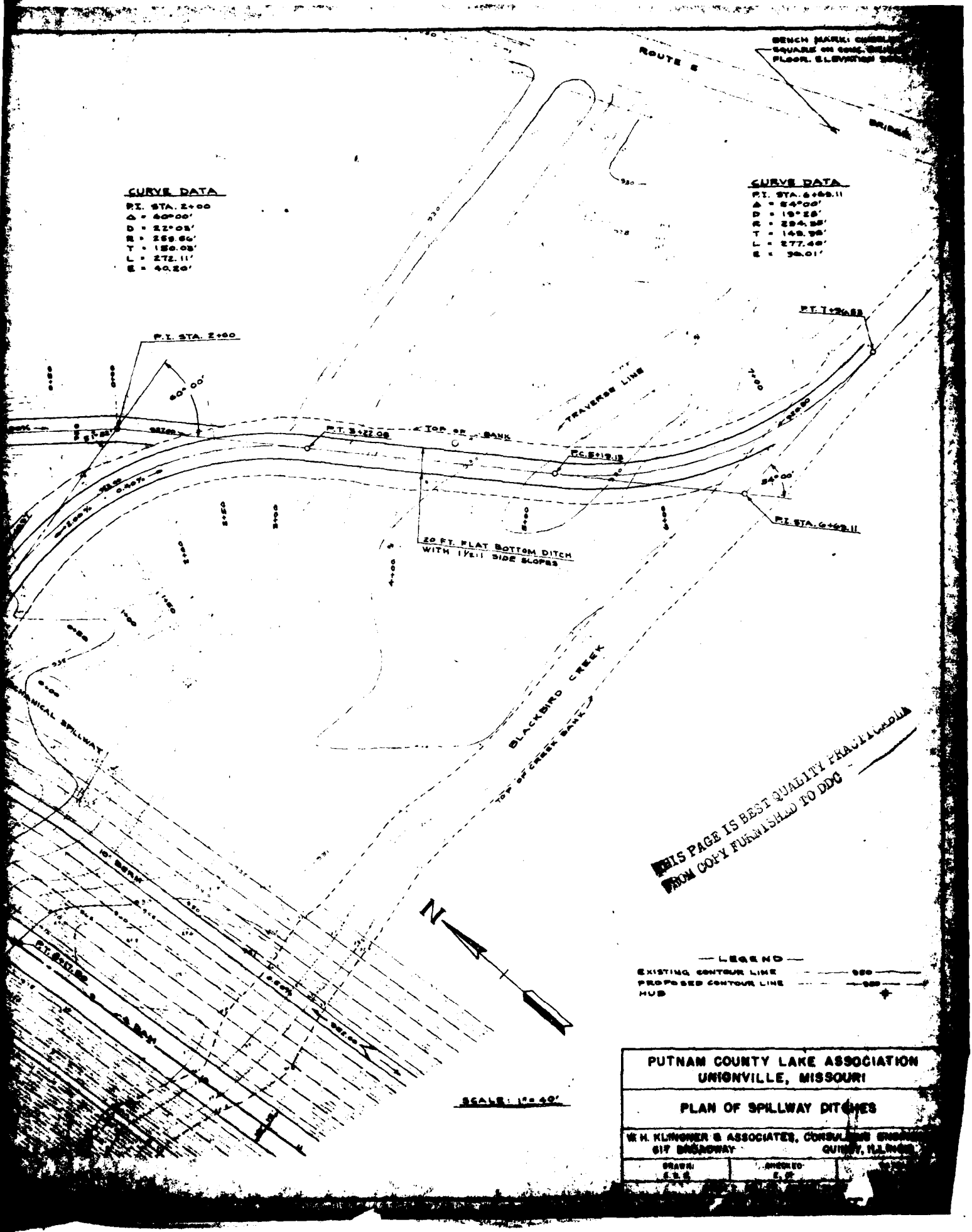

981.04
C-150
F-0
978.34
C-227
F-0
975.67
C-376
F-0
973.00
C-818
F-0
973.00
C-445
F-0
4.00%
978.00
4.00%
1.00%
25'
25'
1.00%
C-514
F-0
6" COMPACTED CRUSHED STONE
976.80
977.50
977.00
C-16
F-5
NORTH END OF DAM

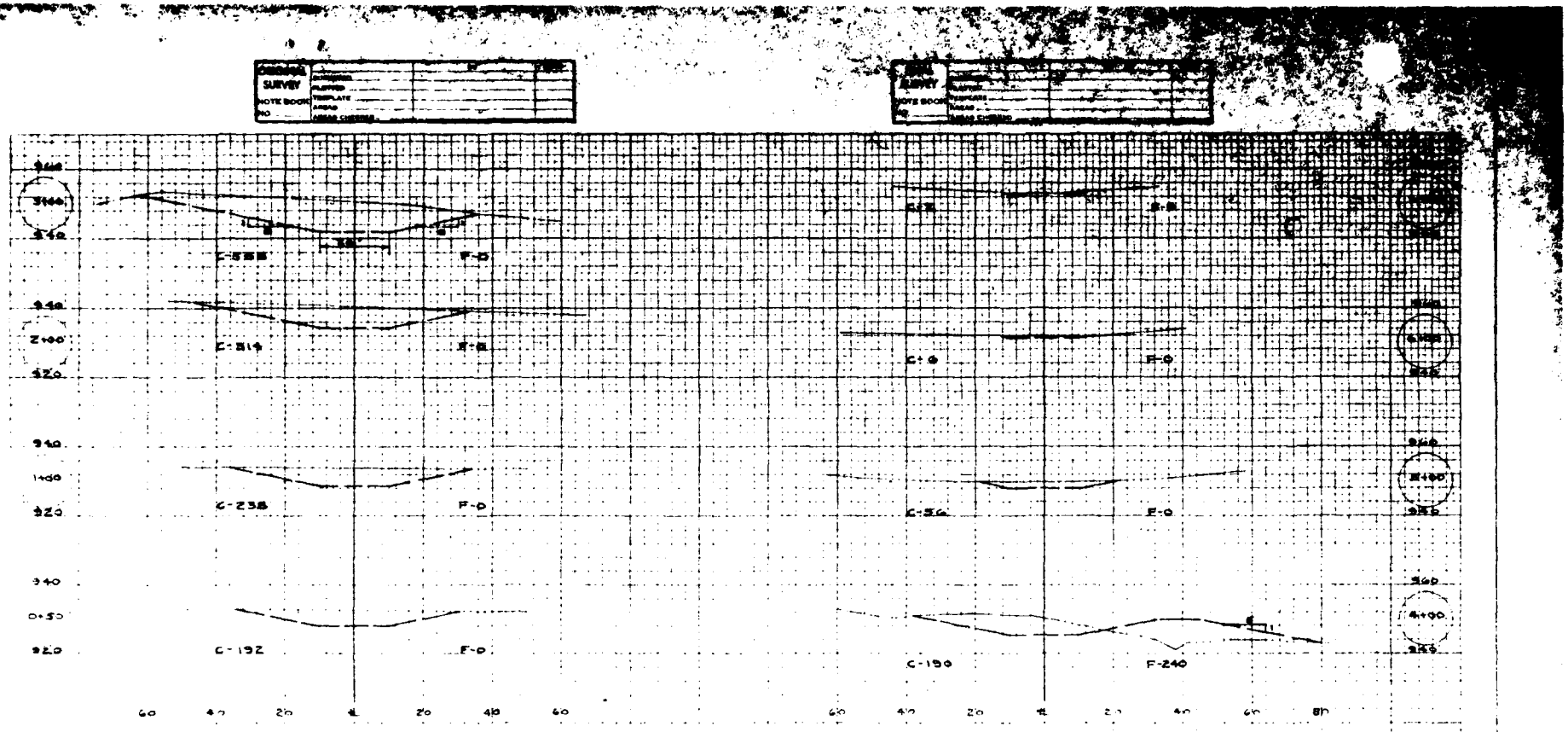
PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI
EMERGENCY SPILLWAY
CROSS SECTIONS



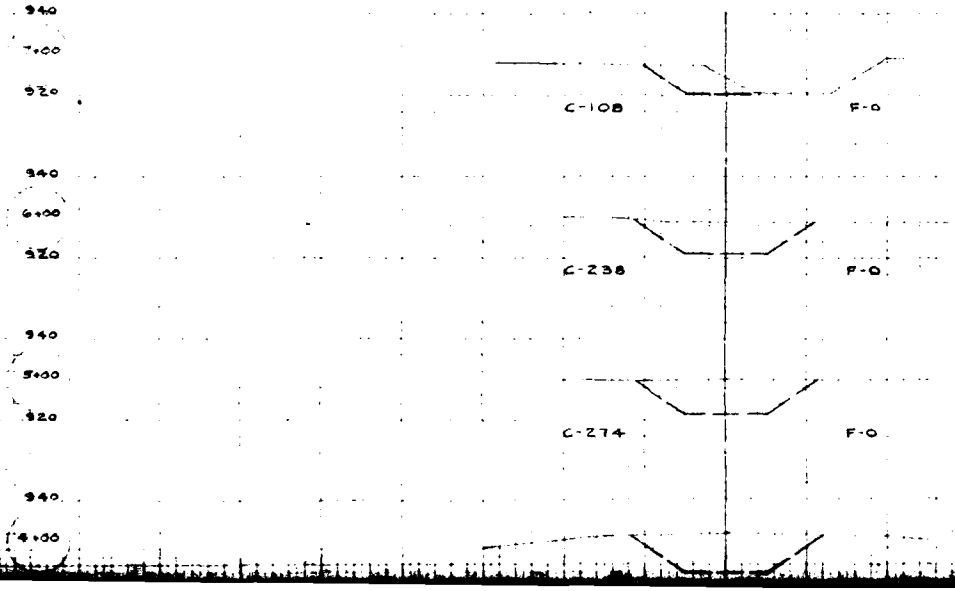
SHEET NO 18 OF 28 SHEETS
PLATE C-15


20 FT. FLAT BOTTOM DITCH
WITH 5:1 SIDE SLOPES
3.22 %
1.00%
17.42%
1.00%
EMERGENCY SPILLWAY DITCH
B.M. SPIKE IN 12" OAK
ELEVATION 949.49
PAVED VALLEY
SEE DETAIL SHEET #15
MECHANICAL SPILLWAY
PT. 2+34.92
PC. 2+ 28
PT. 6+17.78
INLET STRUCTURE
PT. 6+11.82

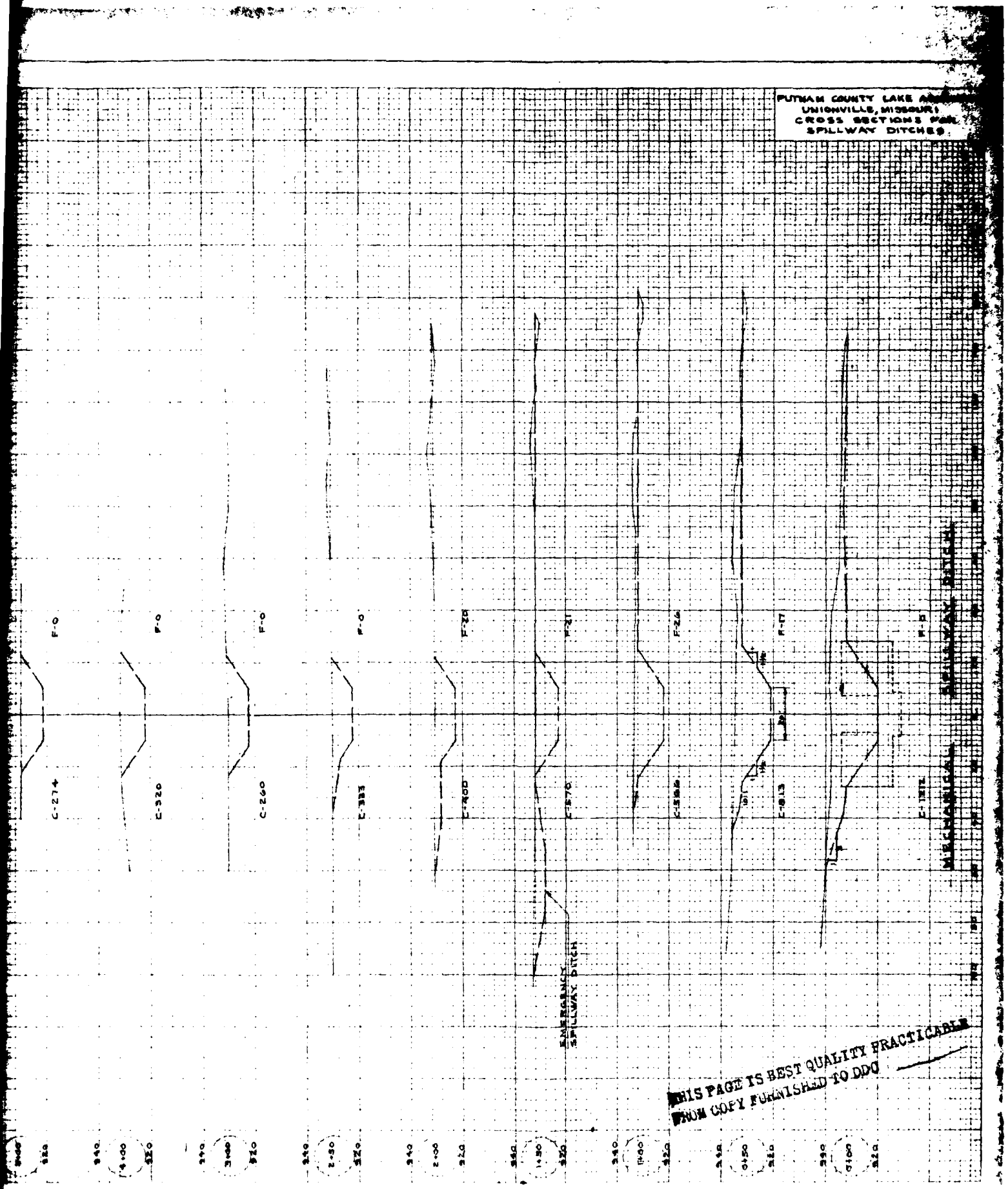




EMERGENCY SPILLWAY DITCH

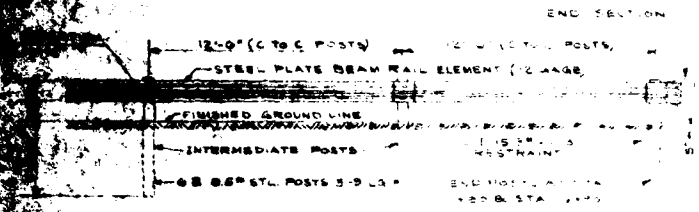


PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI
CROSS SECTIONS FOR
SPILLWAY DITCHES.

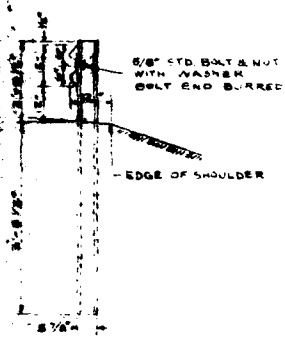


SHEET NO. 18 OF 28 SHEETS

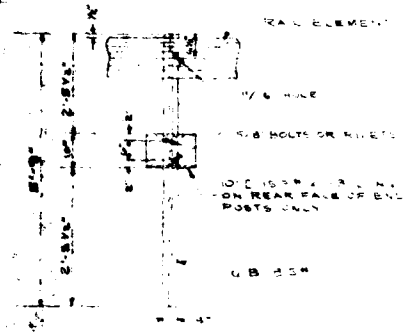
PLATE C-17



END SECTION

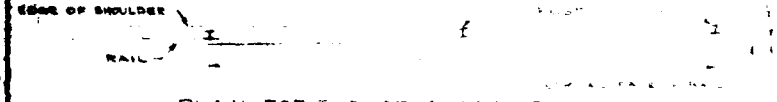


CONNECTION OF RAIL TO POST



FRONT ELEVATION

DETAIL OF STEEL POST

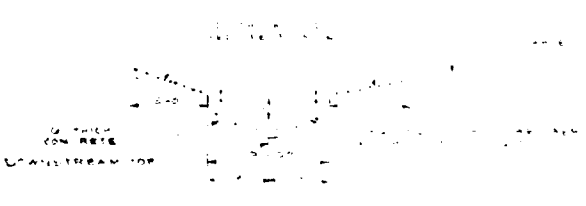


PLAN FOR END OF GUARD RAIL

NOTES:
1 THE RAIL ELEMENTS, STEEL POSTS AND ACCESSORIES SHALL BE GALVANIZED.
2 THE COST OF END SECTIONS SHALL BE INCLUDED IN THE BID PER LINEAL FOOT FOR STEEL PLATE BEAM GUARD RAIL

STEEL PLATE BEAM GUARD RAIL

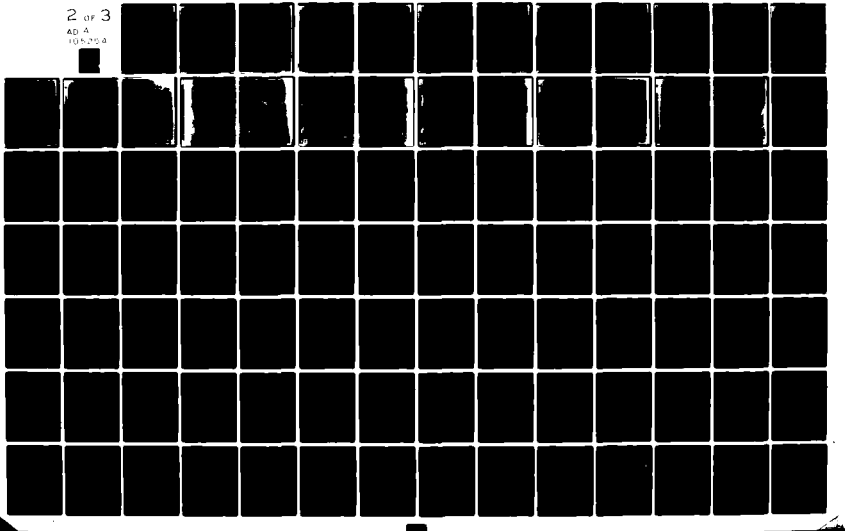
BASE PLAN

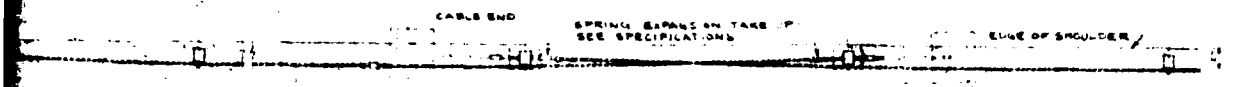


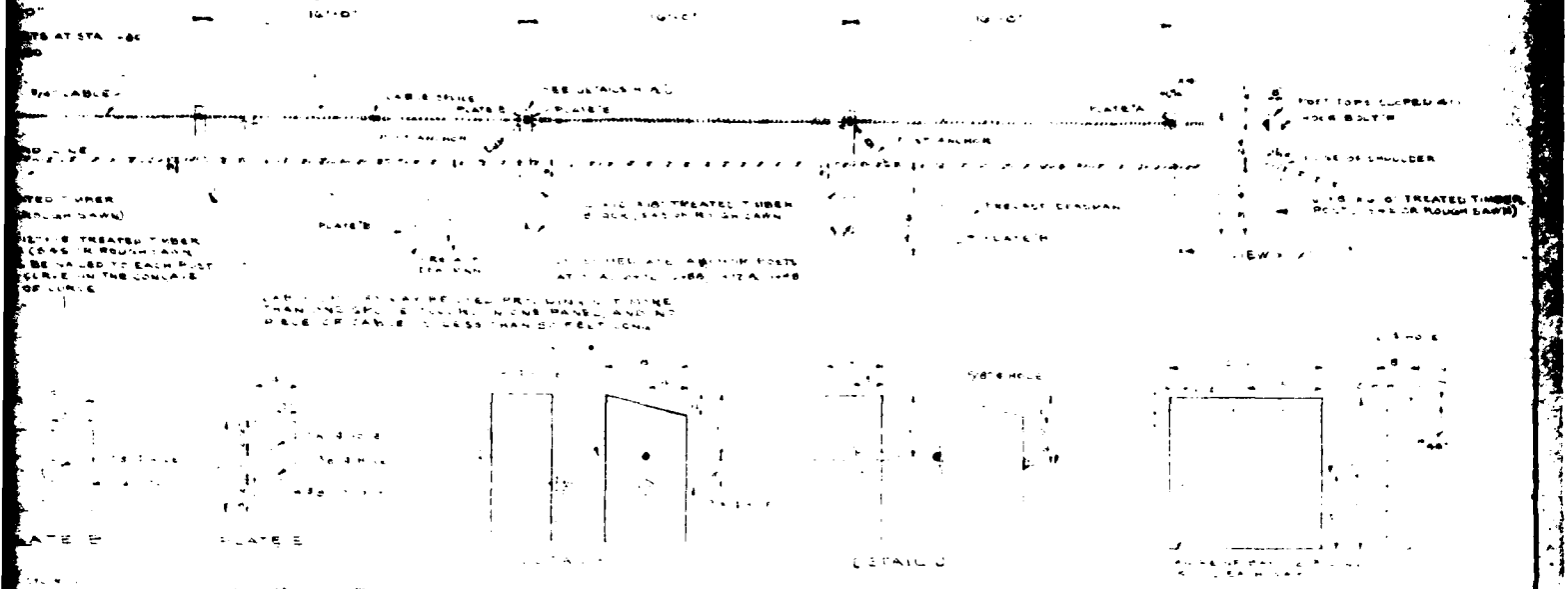
DETAIL OF [illegible]

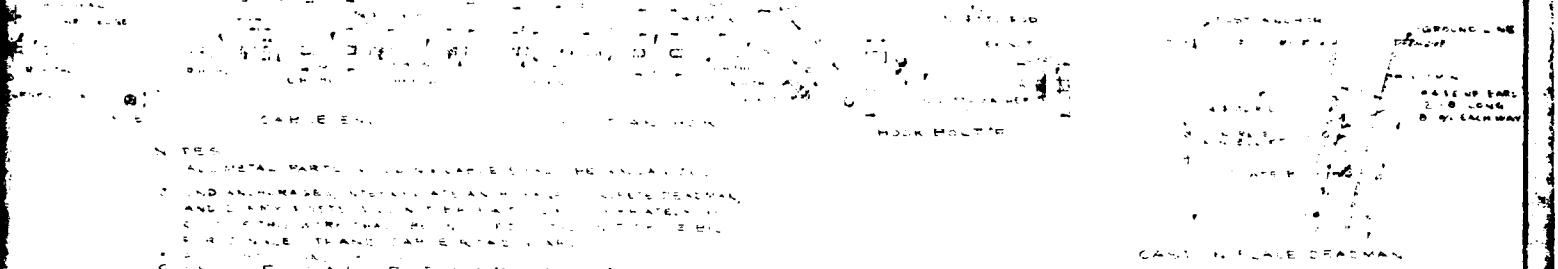
AD-A105 254 HOSKINS-WESTERN-SONDEREGGER INC LINCOLN NE F/G 13/13
NATIONAL DAM SAFETY PROGRAM. LAKE THUNDERHEAD DAM (MO 10007), G--ETC(U)
MAY 80 R S DECKER, G JAMISON, G ULMER DACW43-80-C-0071
UNCLASSIFIED NL

2 OF 3
AD A
105254

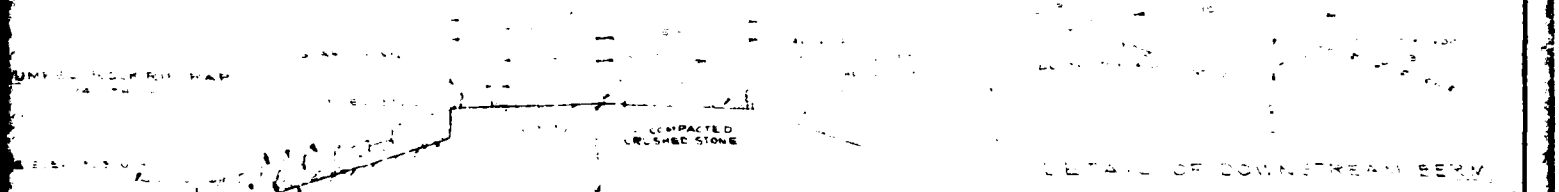








SINGLE CABLE GUARD



OF UPSTREAM BERM, RIP RAP & TOE OF DAM

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

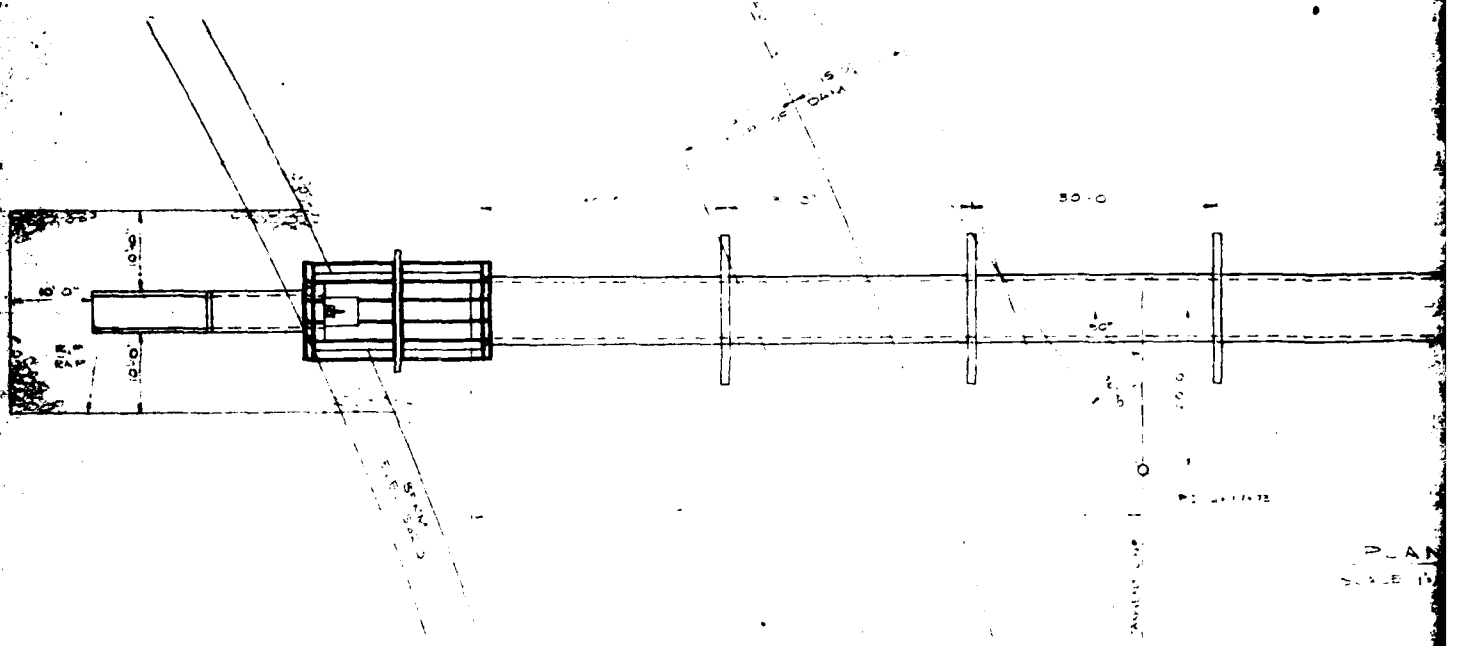
MISCELLANEOUS DETAILS

W H KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
617 BROADWAY QUINCY, ILLINOIS

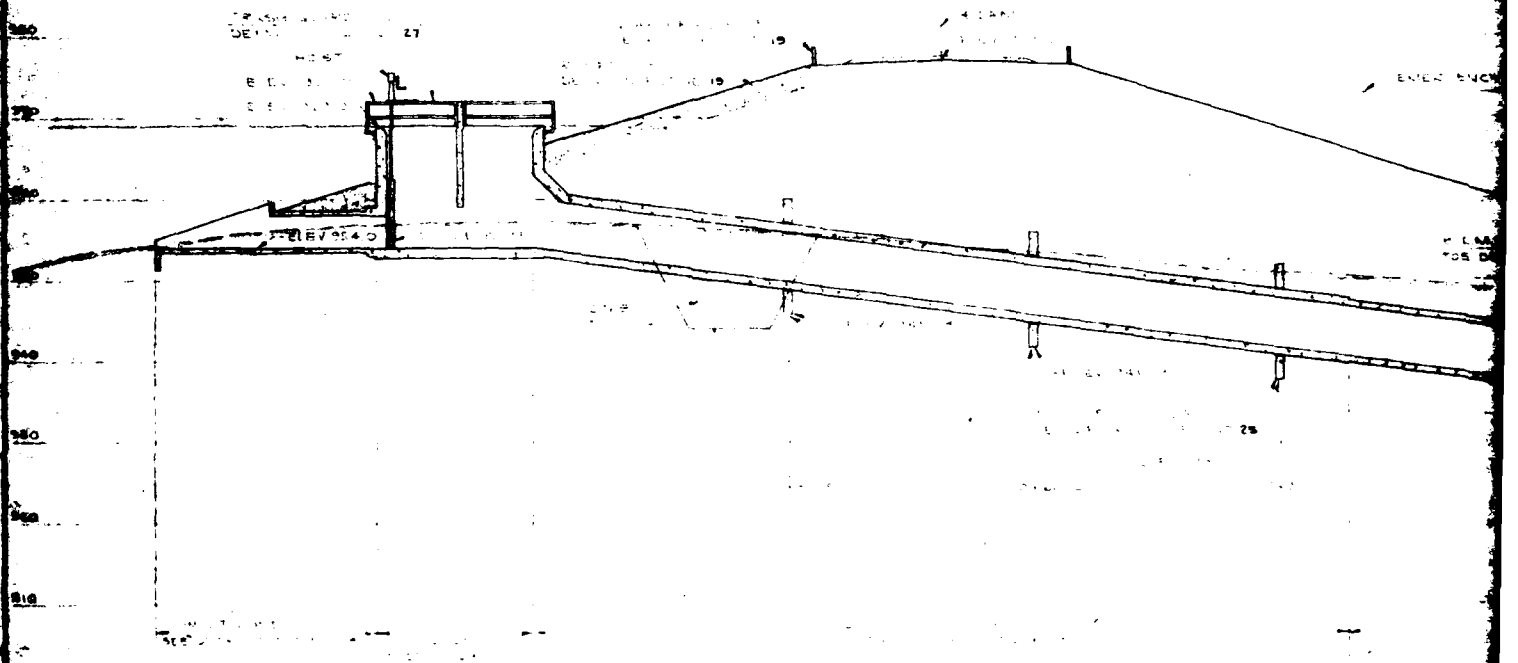
DRAWN	CHECKED	DATE
A B H	E C	MARCH 1963

SHEET NO 19 OF 28 SHEETS

PLATE C-18

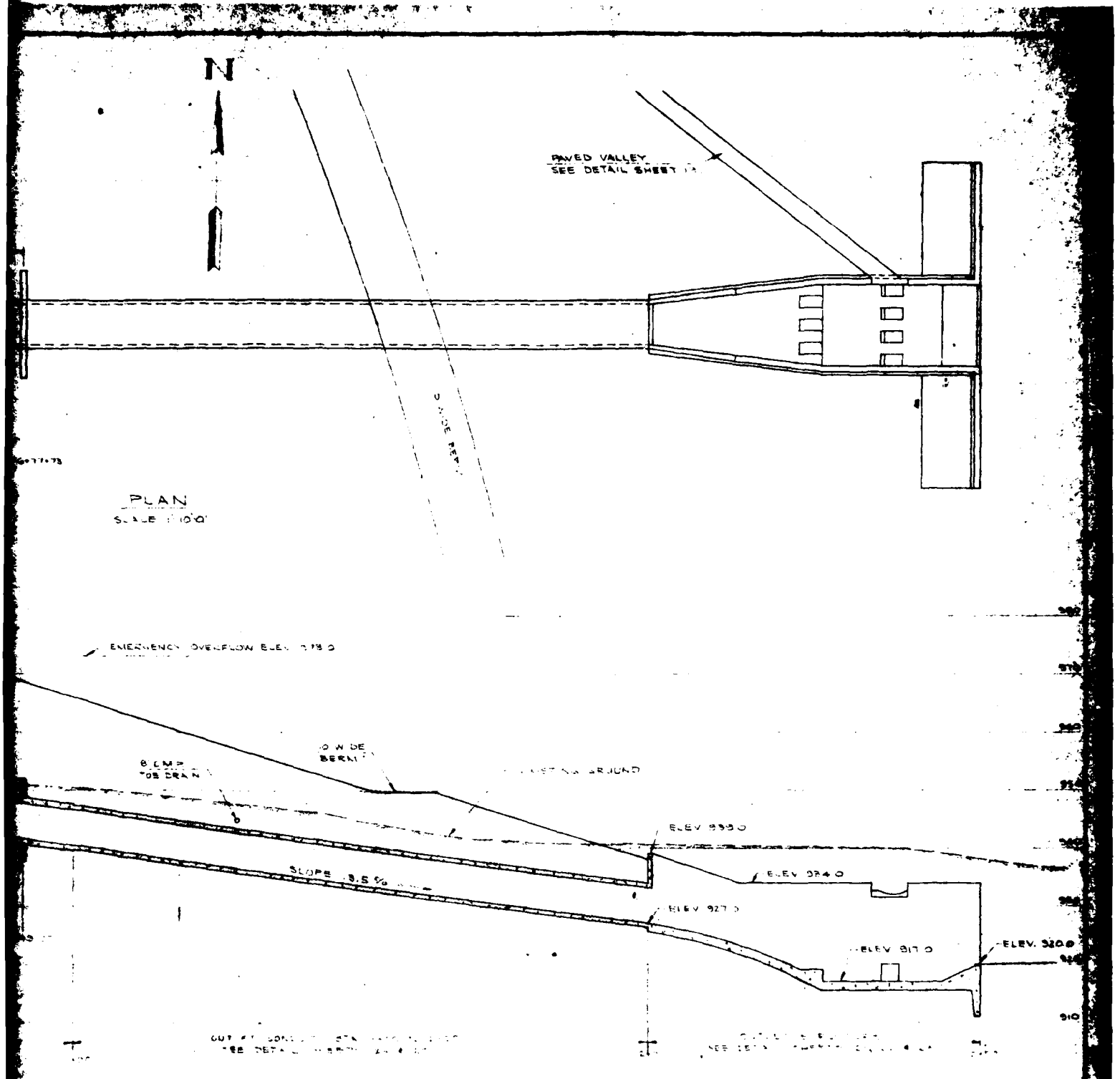


PLAN



2. ALL

3. ALL



CENTERLINE OF STREET

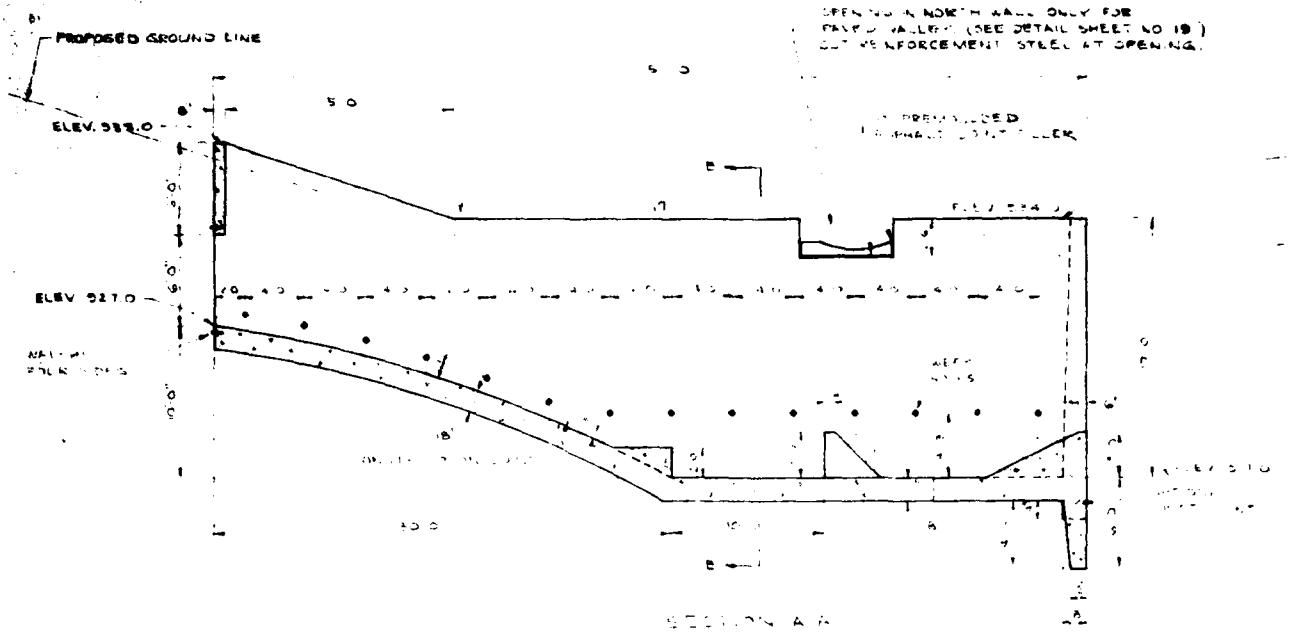
PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

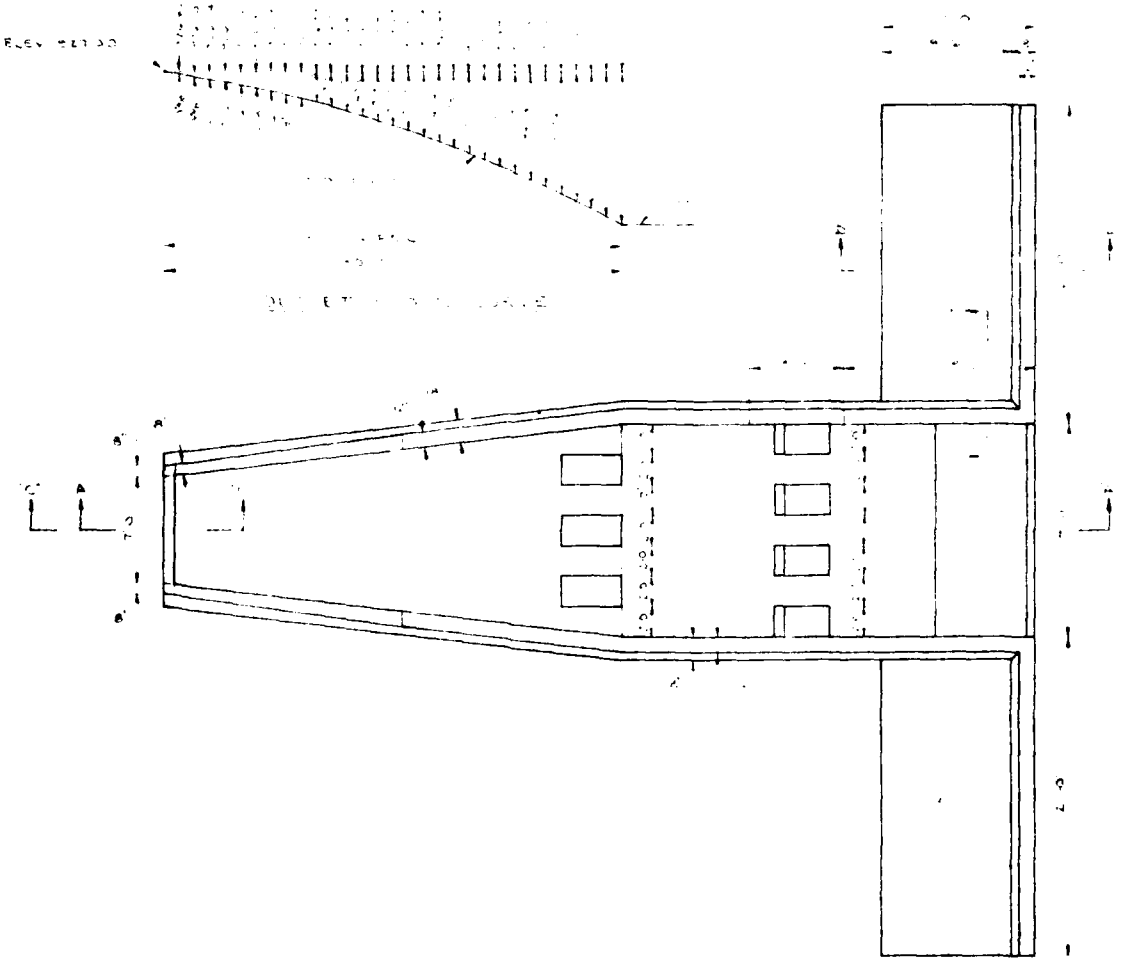
MECHANICAL SPILLWAY
AND OUTLET WORKS

W. H. KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
617 BROADWAY QUINCY, ILLINOIS

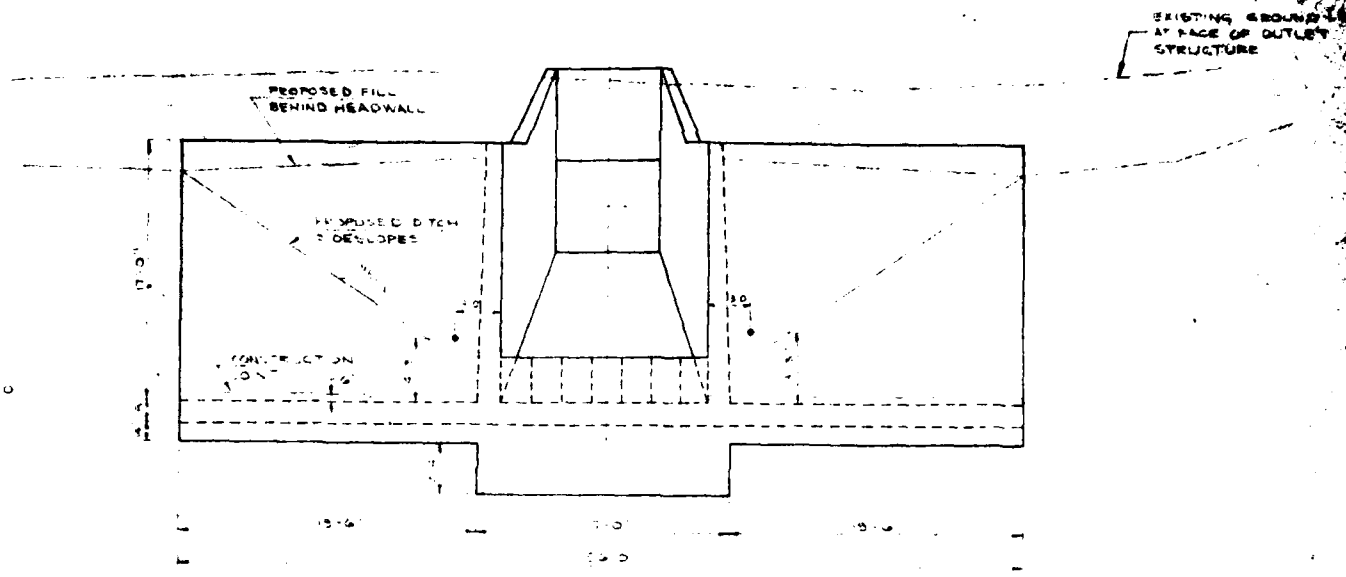
DRAWN	CHECKED	DATE
A. K. Stockton		MARCH, 1960

SHEET NO. 10 OF 10 SHEETS





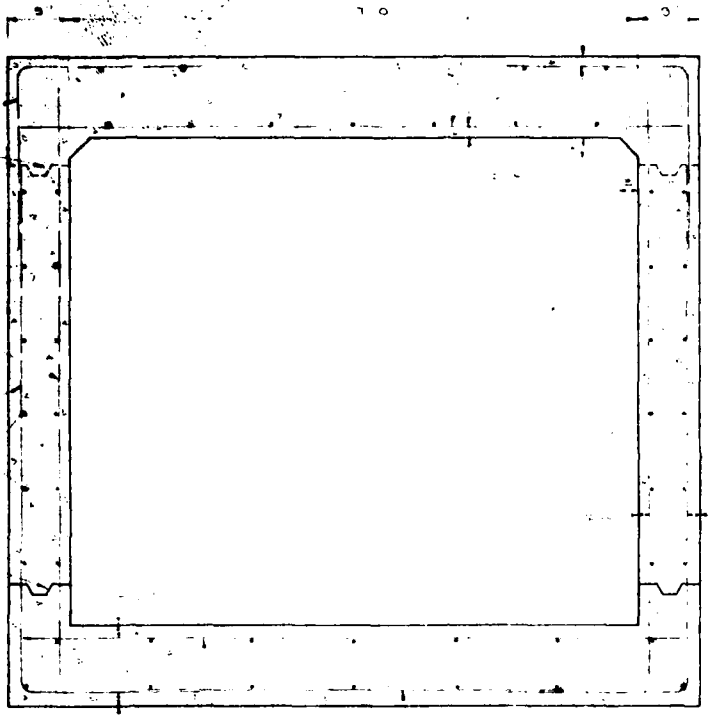
PLAN

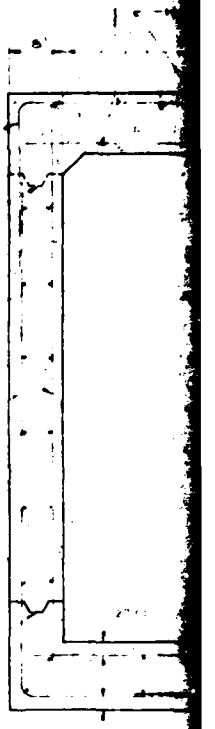


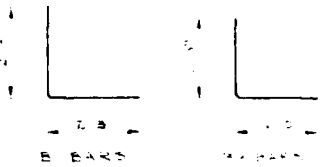
END VIEW

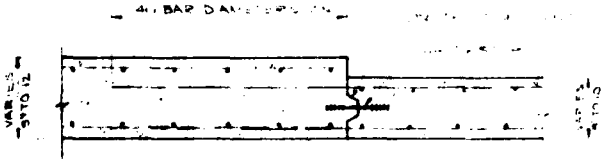
PUTNAM COUNTY LAKE ASSOCIATION UNIONVILLE, MISSOURI		
OUTLET STRUCTURE		
W. H KLINGNER & ASSOCIATES, CONSULTING ENGINEERS 617 BROADWAY QUINCY, ILLINOIS		
DRAWN	CHECKED	DATE MARCH, 1968
SHEET NO 21 OF 28 SHEETS		

PLATE C-20

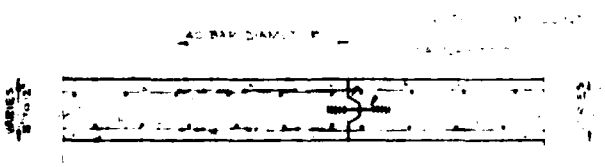




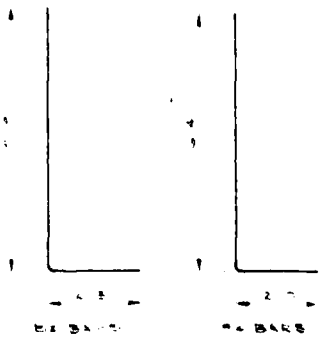




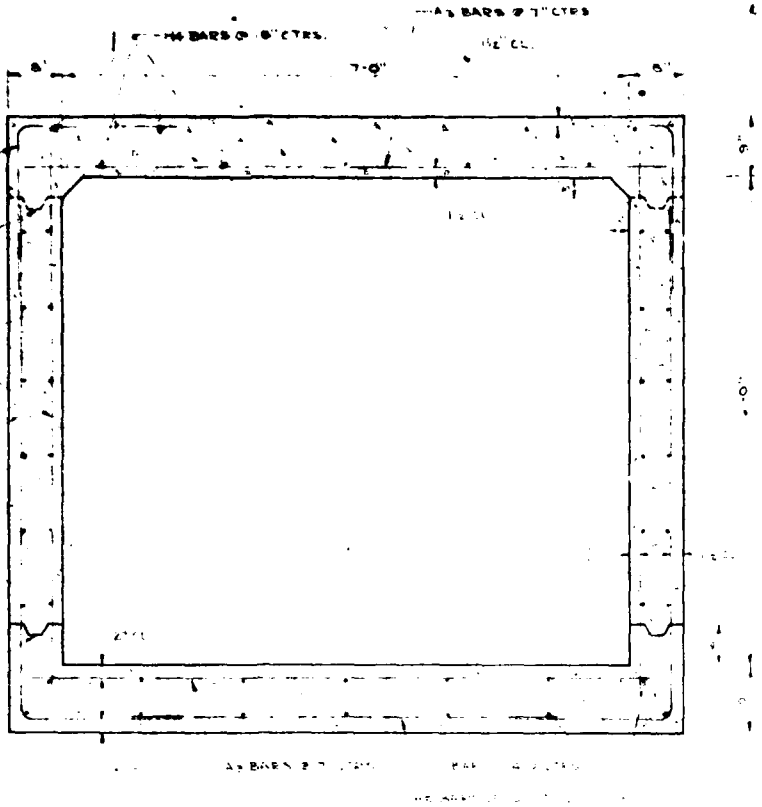
CONSTRUCTION JOINT @ STA



TYPICAL CONSTRUCTION JOINT



REINFORCEMENT BAR DETAIL



TYPICAL SECTION - STA. [illegible]

BILL OF MATERIALS
CONDUIT - STA. 0+00 TO STA. 2+00

MARK	NO. REQ'D.	LENGTH	SIZE	NOTES
A1	338	6'-2"	#6	STRAIGHT
A2	52	5'-8"	#4	STRAIGHT
A3	348	8'-0"	#7	STRAIGHT
B1	314	4'-6"	#5	SEE DETAIL
B2	328	8'-8"	#5	SEE DETAIL
B3	324	4'-0"	#5	SEE DETAIL
B4	324	8'-4"	#5	SEE DETAIL
B5	2	5'-0"	#5	SEE DETAIL
B6	2	5'-3"	#5	SEE DETAIL
B7	2	5'-9"	#5	SEE DETAIL
B8	2	6'-3"	#5	SEE DETAIL
B9	2	6'-6"	#5	SEE DETAIL
B10	2	6'-9"	#5	SEE DETAIL
B11	2	7'-3"	#5	SEE DETAIL
H1	—	VARIES	#6	SEE DETAIL - 2635 L.F. REQ'D.
H2	—	VARIES	#4	STRAIGHT - 247 L.F. REQ'D.
H3	—	VARIES	#5	STRAIGHT - 247 L.F. REQ'D.
H4	—	VARIES	#7	STRAIGHT - 340 L.F. REQ'D.
H5	—	VARIES	#5	STRAIGHT - 450 L.F. REQ'D.
H6	4	6'-3"	#5	STRAIGHT
H7	4	5'-9"	#5	STRAIGHT
H8	4	4'-0"	#5	STRAIGHT
V1	204	7'-8"	#4	STRAIGHT
V2	204	8'-8"	#4	STRAIGHT
REINFORCING STEEL				39,391 LBS.
CONCRETE				98.4 CU. YDS.

QUANTITIES SHOWN FOR H BARS ON PLAN PORTION DO NOT INCLUDE LAP AT CONSTRUCTION JOINTS

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

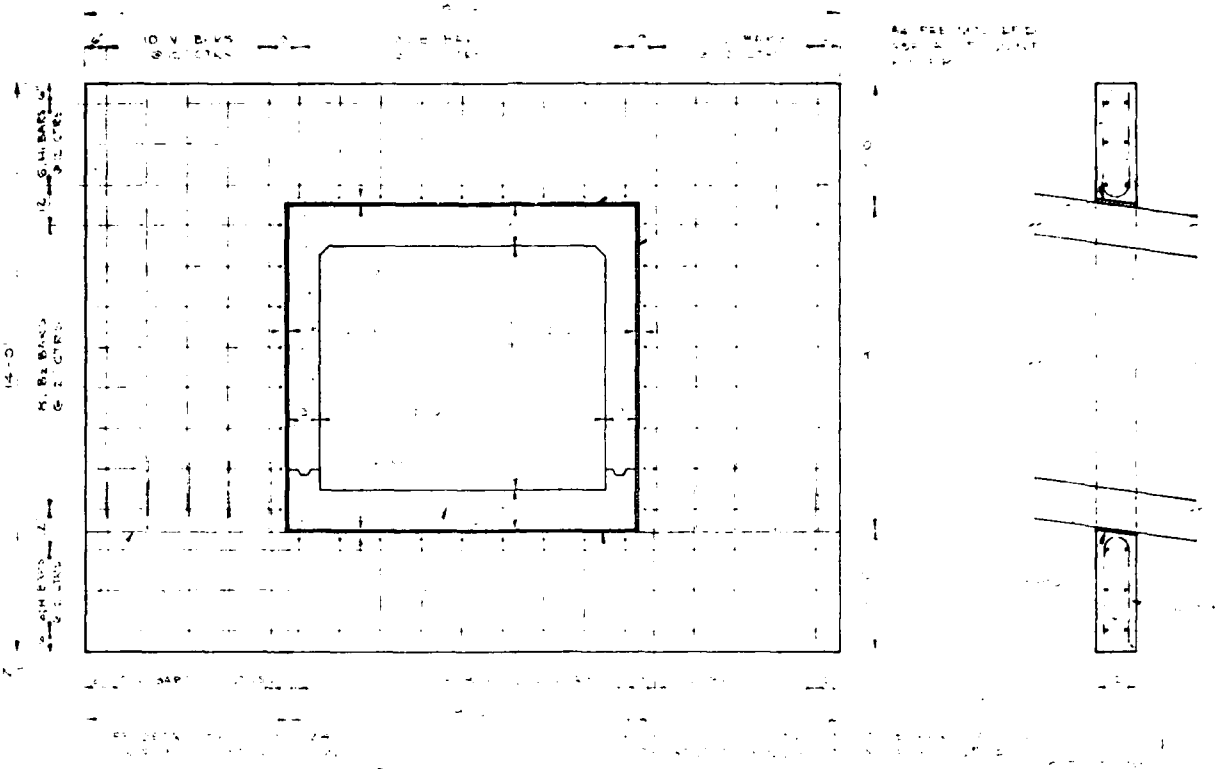
OUTLET CONDUIT

W. H. KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
617 BROADWAY QUINCY, ILLINOIS

DRAWN	CHECKED	DATE
A. E. Stockton		MARCH, 1968

SHEET NO. 24 OF 28 SHEETS

PLATE C-21



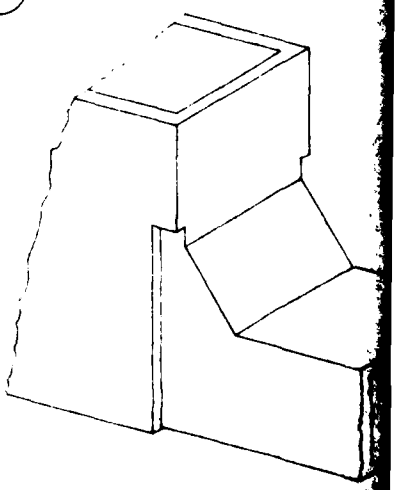
CONSTRUCTION JOINT
WIDENED EXCEPT
UNDER CONDUITS

ELEVATION

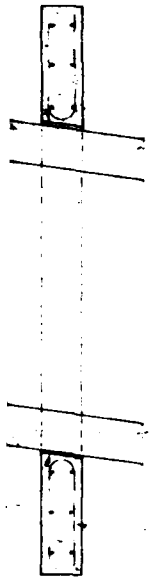
MARK	NO REQD	LENGTH	SIZE	SPACING
H1	54		#4	
V1	60		#4	
V2	60		#4	
B1	24		#4	
B2	44		#4	

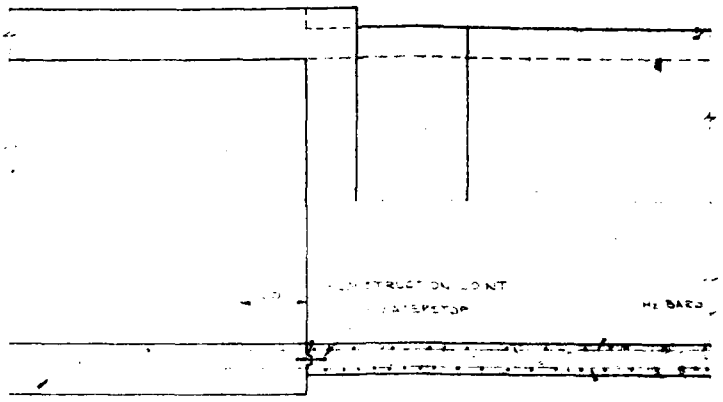
REINFORCEMENT STEEL

CONCRETE

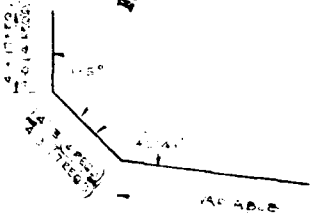


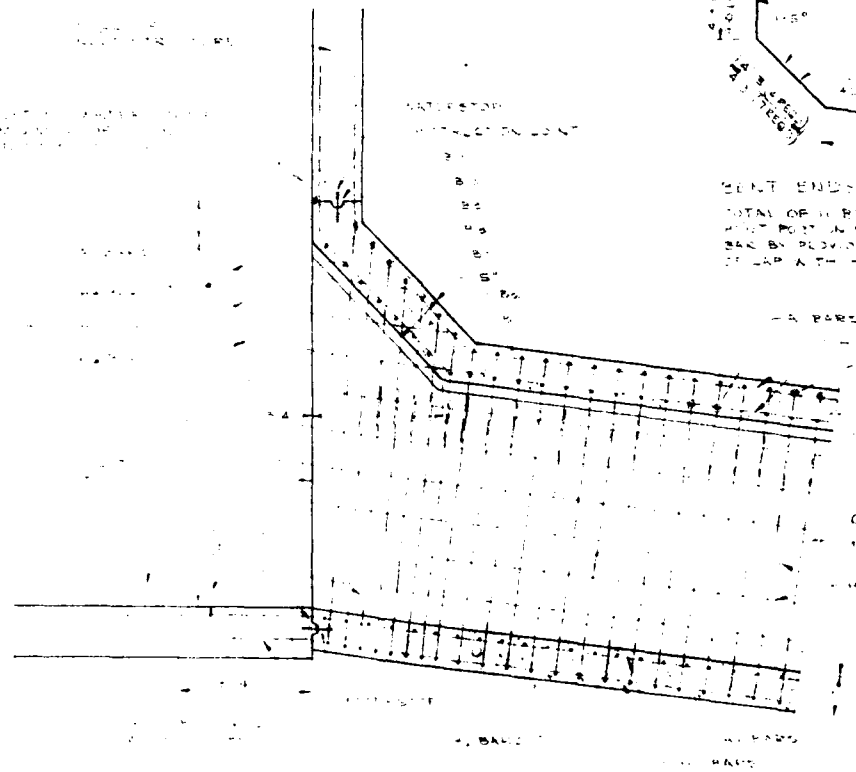
PERSPECTIVE VIEW
JUNCTION OF CONDUIT & INLET

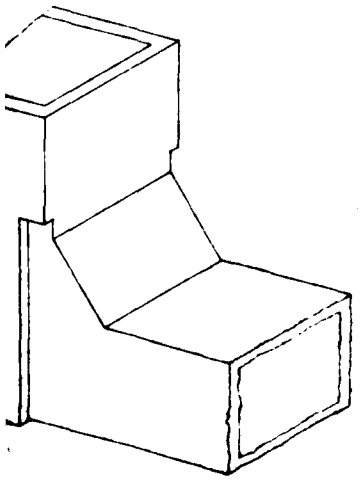




PLAN







PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

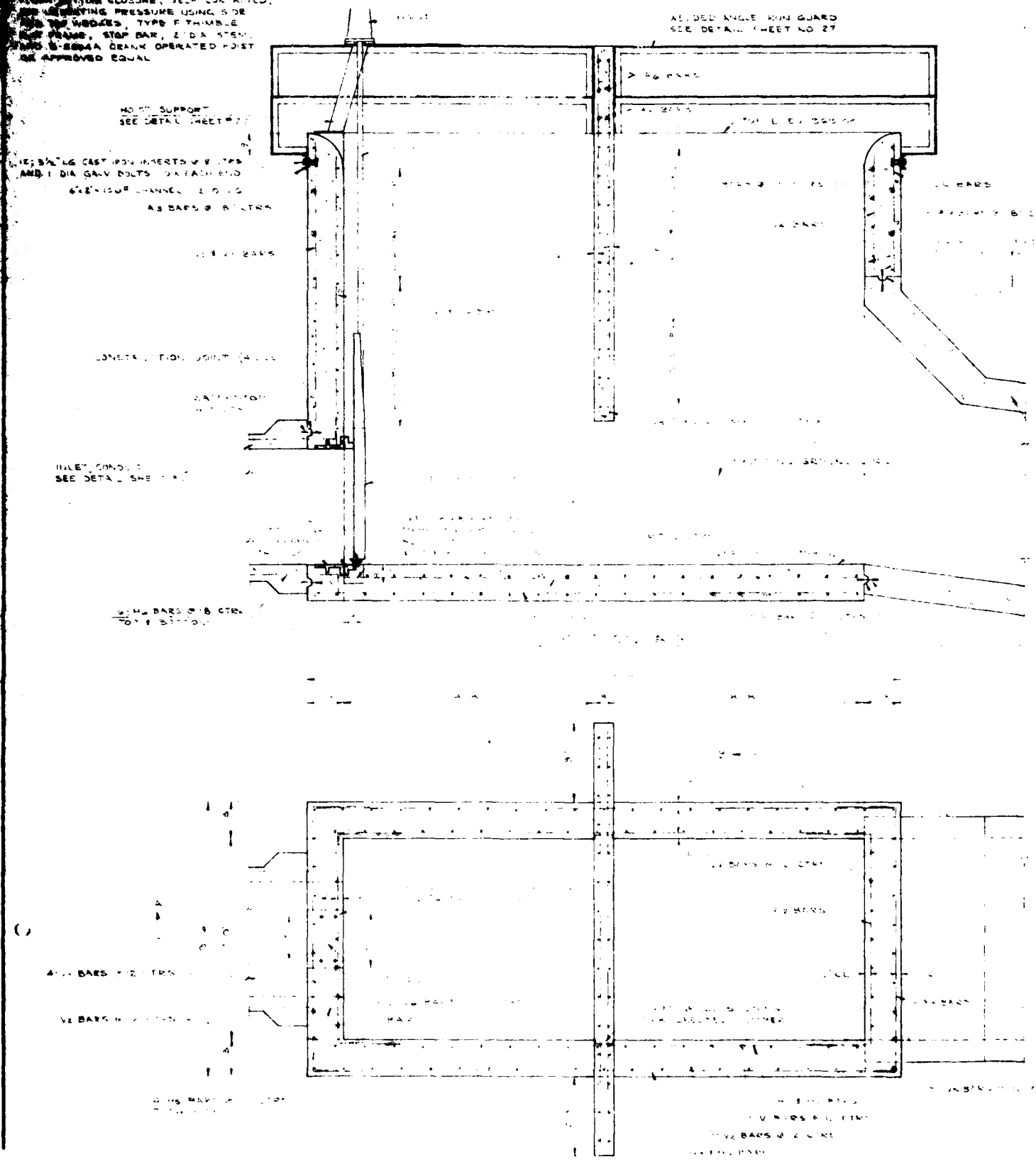
OUTLET CONDUIT

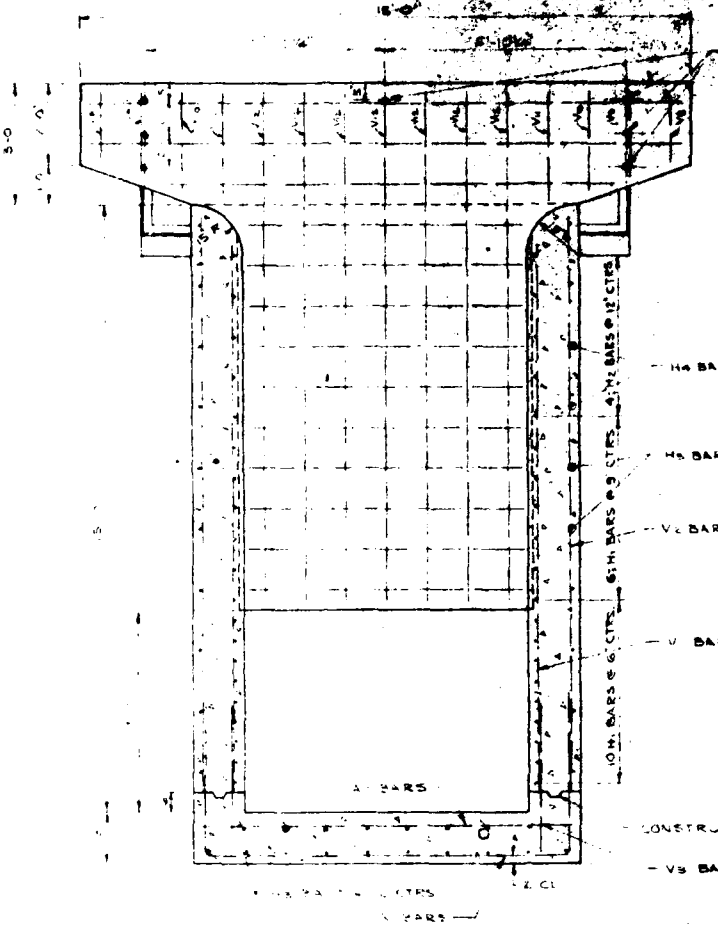
W H KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
617 BROADWAY QUINCY, ILLINOIS

DRAWN	CHECKED	DATE
A. K. Stricklan		MARCH, 1965

SHEET NO 25 OF 28 SHEETS

PLATE C-25





SECTION B-B

MARK	NO. REQ'D	LENGTH	SIZE	NOTES
A	13	5' 2"	#6	SEE DETAILS
A1	4	11'-7"	#5	" "
A2		13' 2"	#4	" "
A4		7' 0"	#4	STRAIGHT
A5		11' 6"	#4	"
A6		4' 6"	#4	
A7		3' 0"	#4	
B	8	15' 6"	#5	
B1	8	7' 0"	#5	
B2	20	13' 6"	#4	
B4	8	21' 2"	#4	
H5	8	6' 8"	#5	SEE DETAILS
H6	6	4' 8"	#5	" "
V1	45	13' 6"	#5	STRAIGHT
V2	44	14' 2"	#4	
V3	40	8' 3"	#4	
V4		4' 3"	#5	
V5	10	4' 3"	#4	
V6	5	10' 0"	#5	
V7		10' 0"	#4	
V8	4	9' 3"	#4	
V9	4	2' 3"	#4	
	4	1' 6"	#4	
	4	3' 3"	#4	
V12	4	1' 6"	#4	

REINFORCEMENT STEEL 1696 LBS
CONCRETE 43.0 CU YDS

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

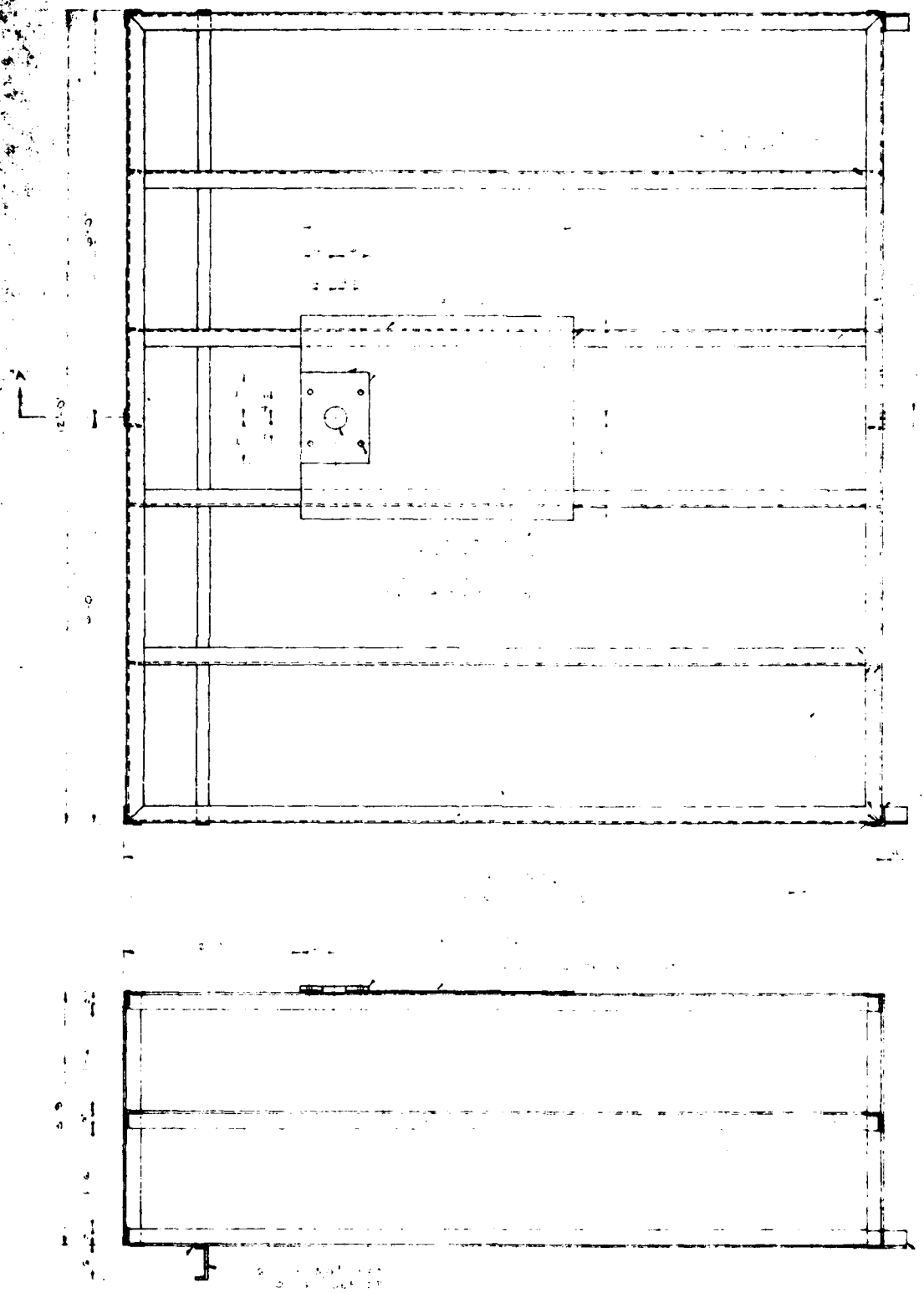
INLET STRUCTURE

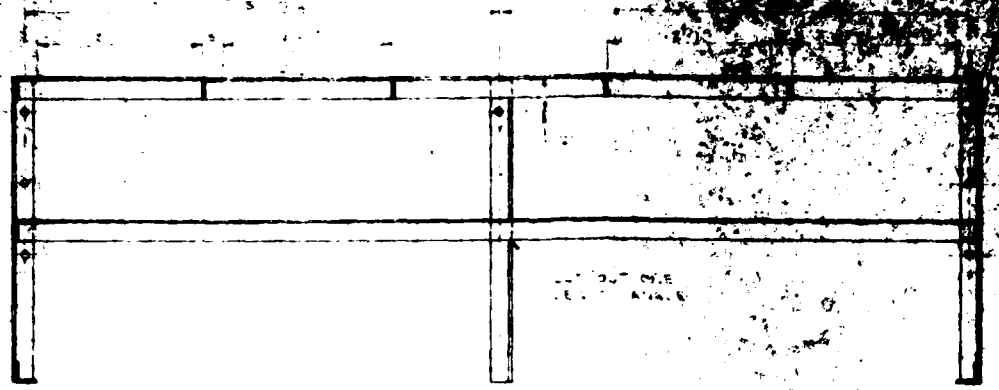
W. H. KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
617 BROADWAY QUINCY, ILLINOIS

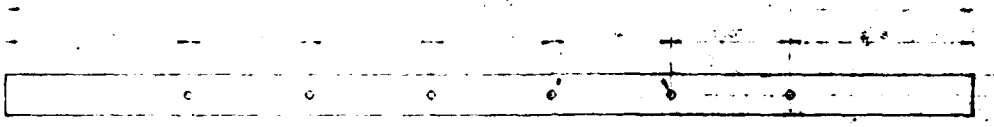
DRAWN	CHECKED	DATE
A. K. Stockton		MARCH, 1965

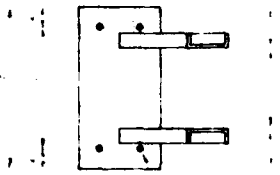
SHEET NO. 20 OF 20 SHEETS

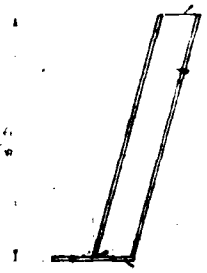
PLATE C-23



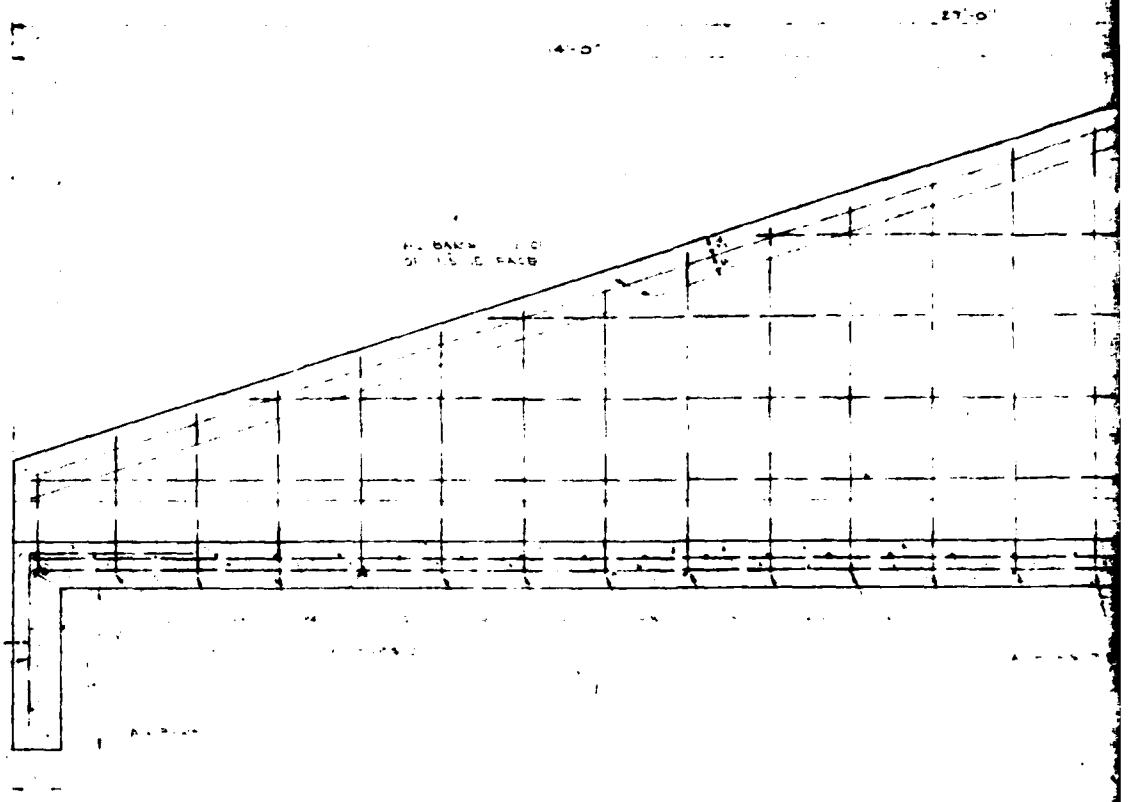


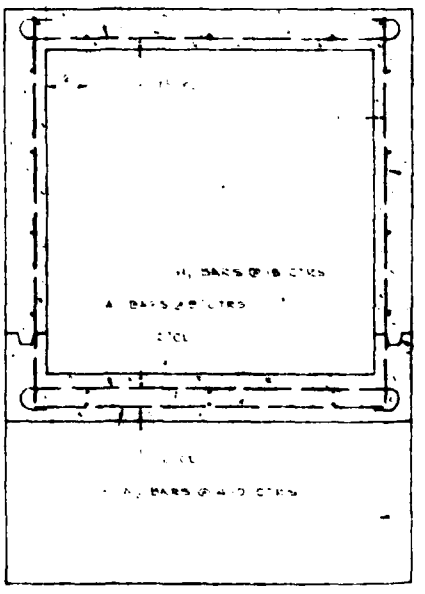






PUTNAM COUNTY LAKE ASSOCIATION UNIONVILLE, MISSOURI		
INLET STRUCTURE		
W. H. KLINGNER & ASSOCIATES, CONSULTING ENGINEERS 617 BROADWAY QUINCY, ILLINOIS		
DRAWN	CHECKED	DATE MARCH, 1969

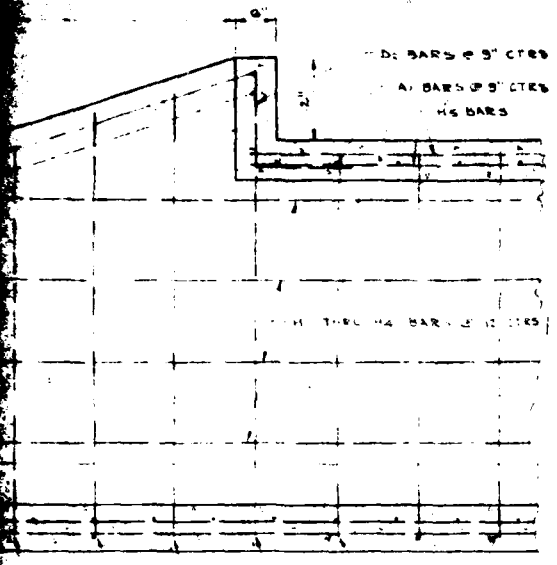


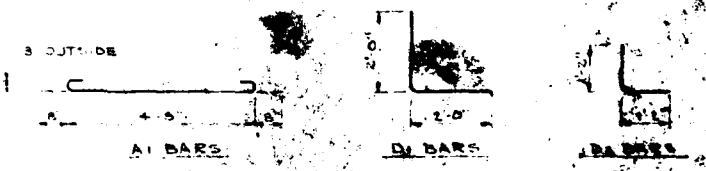


MARK	NO REQD	LENGTH	SIZE	NOTES
A	55	4 0	#	
A1	5	4	#	
B1	7	4	#	
B2	1	2	#	
B3	4	2	#	
B4	2	2	#	
B5	2	1	#	
B6	5	1	#	
B7	2	1	#	

REINFORCEMENT

CONCRETE





REINFORCEMENT BAR DETAILS

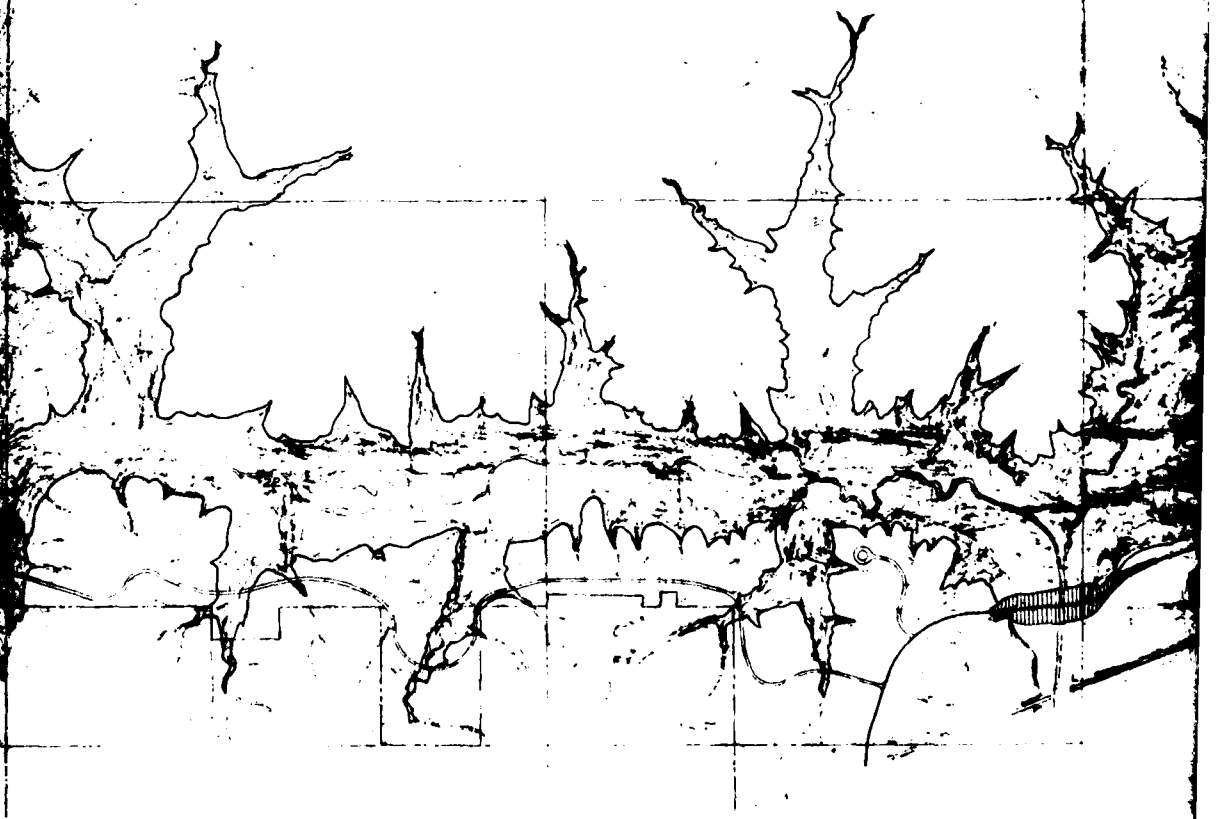
PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

INLET CONCRETE

IAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI
THUNDERHEAD SEWERAGE IMPROVEMENTS

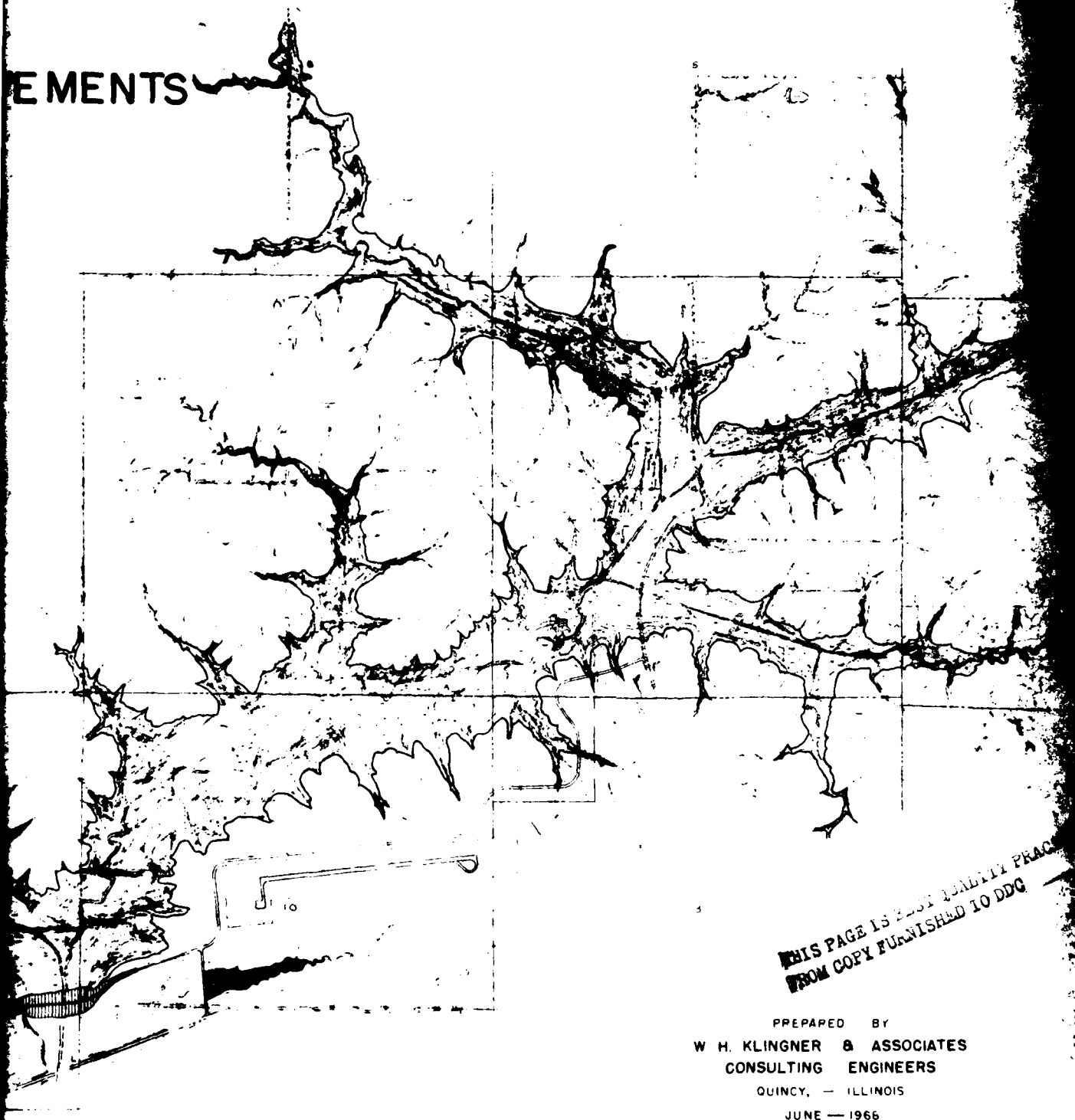
INDEX

PROJECT NO. 06-1-00481



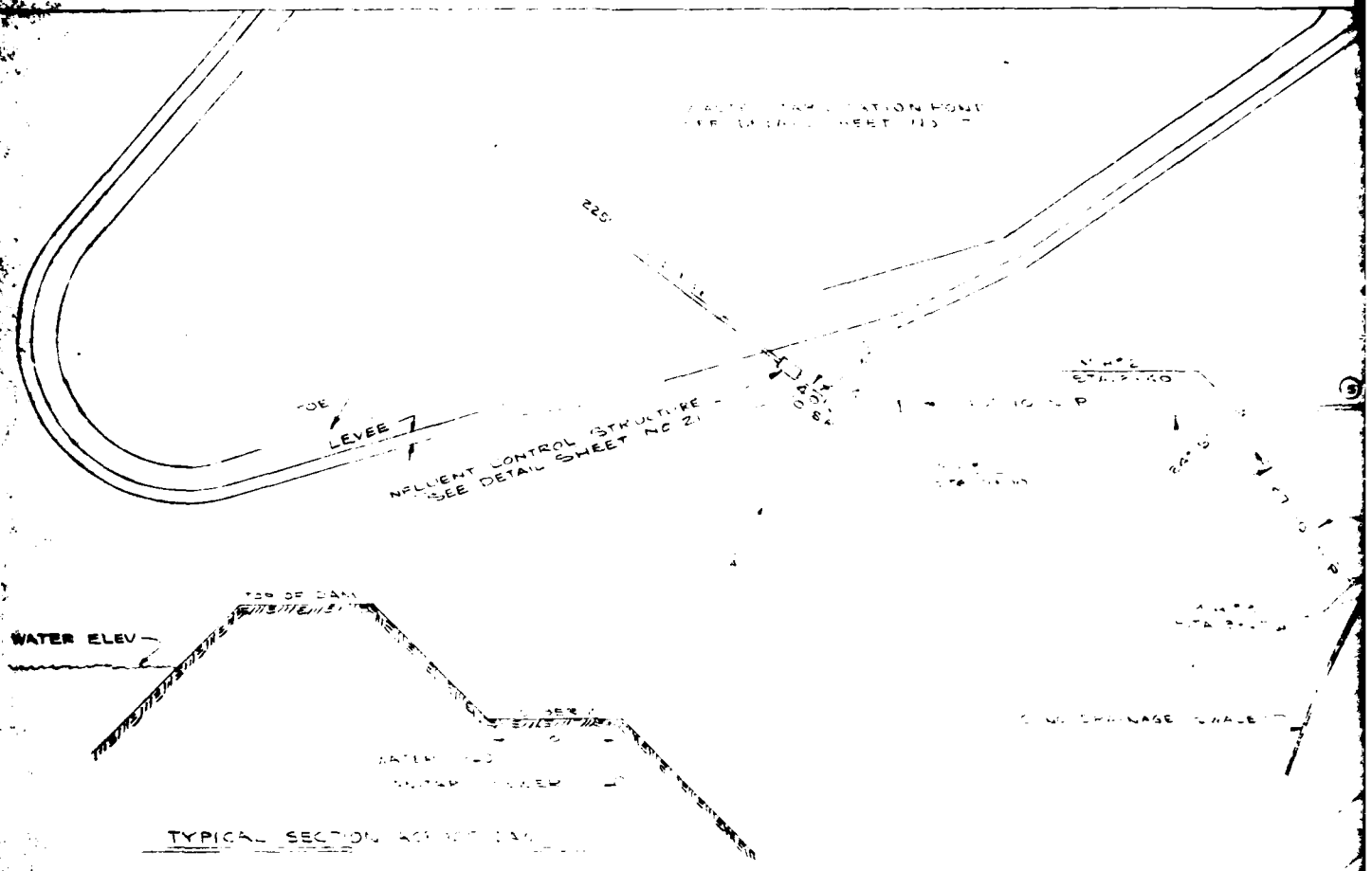
CIATION

EMENTS

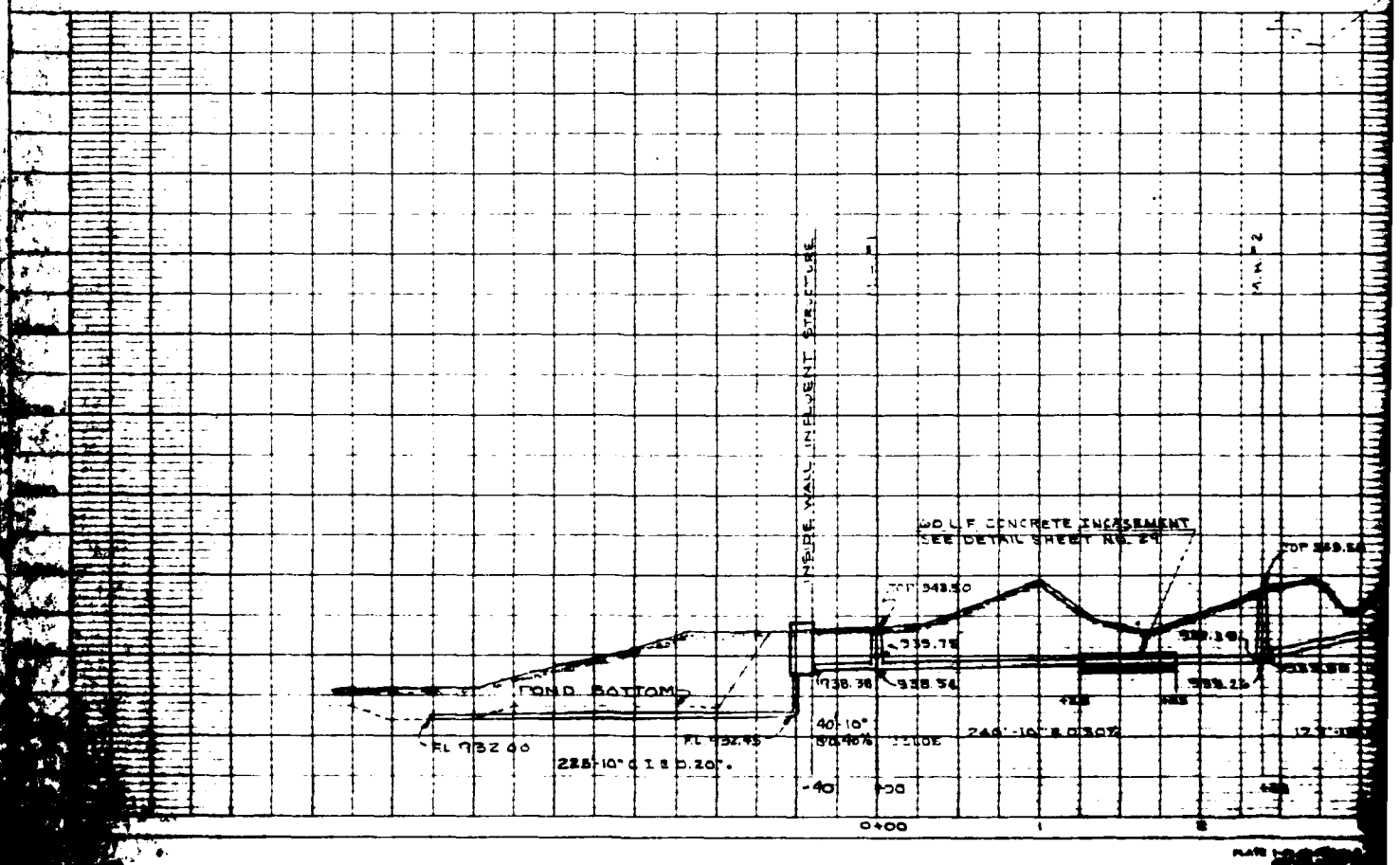


PREPARED BY
W H. KLINGNER & ASSOCIATES
CONSULTING ENGINEERS
QUINCY, — ILLINOIS
JUNE — 1966

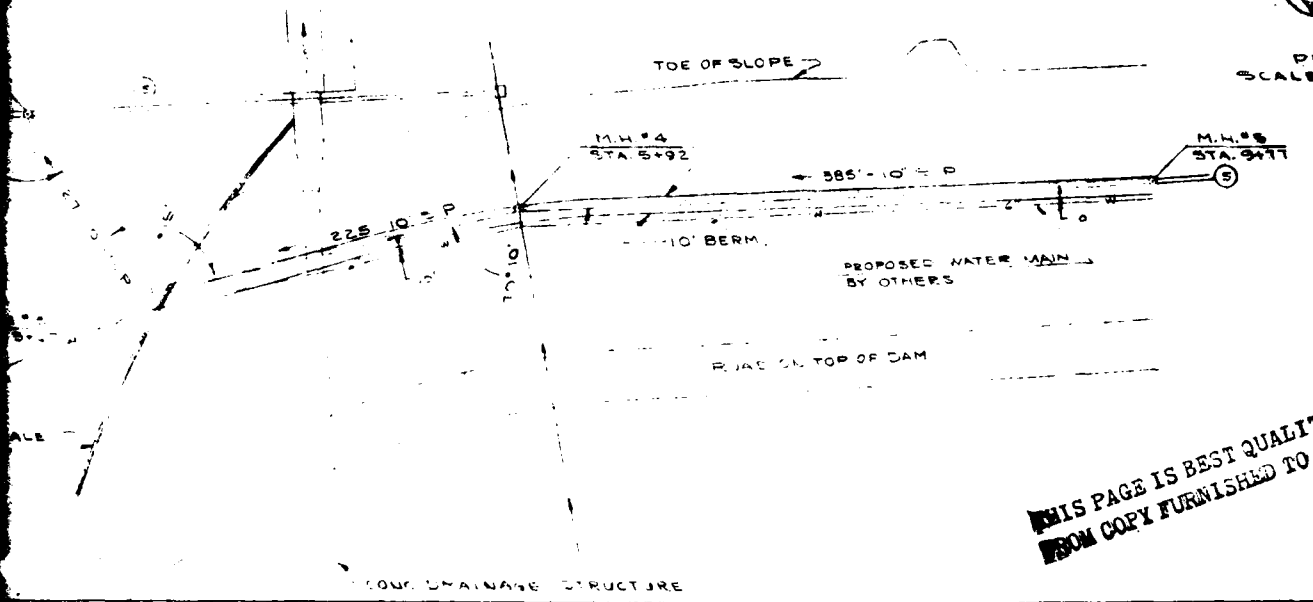
PLATE C-20



TYPICAL SECTION

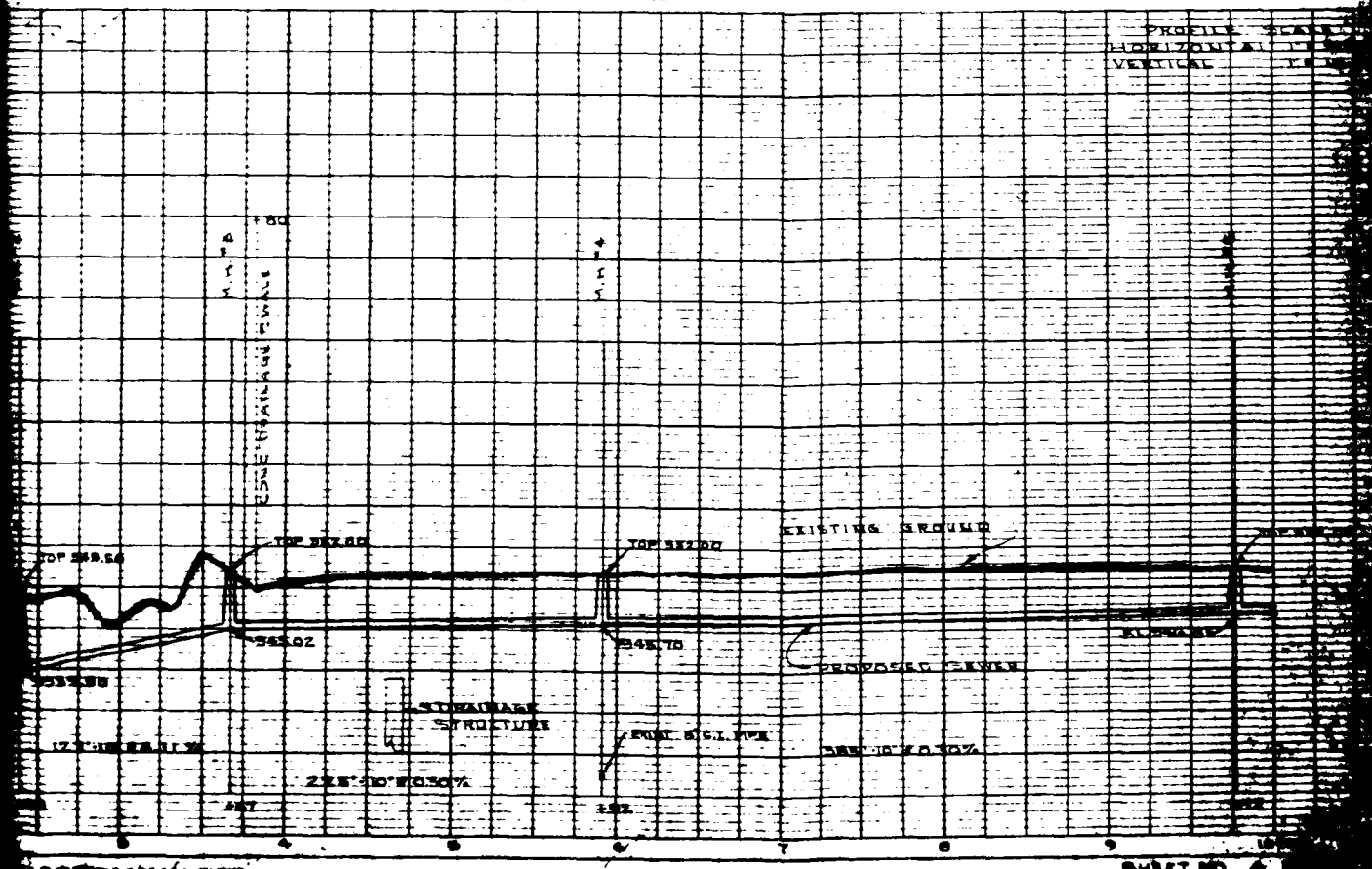


PUTNAM COUNTY
UNIONVILLE
SANITARY
PLAN AND
W.H. KLINGNER, ESQ.
617 BROADWAY
DRAWN D.E.H.
DESIGN W.H.
REVISED [illegible]

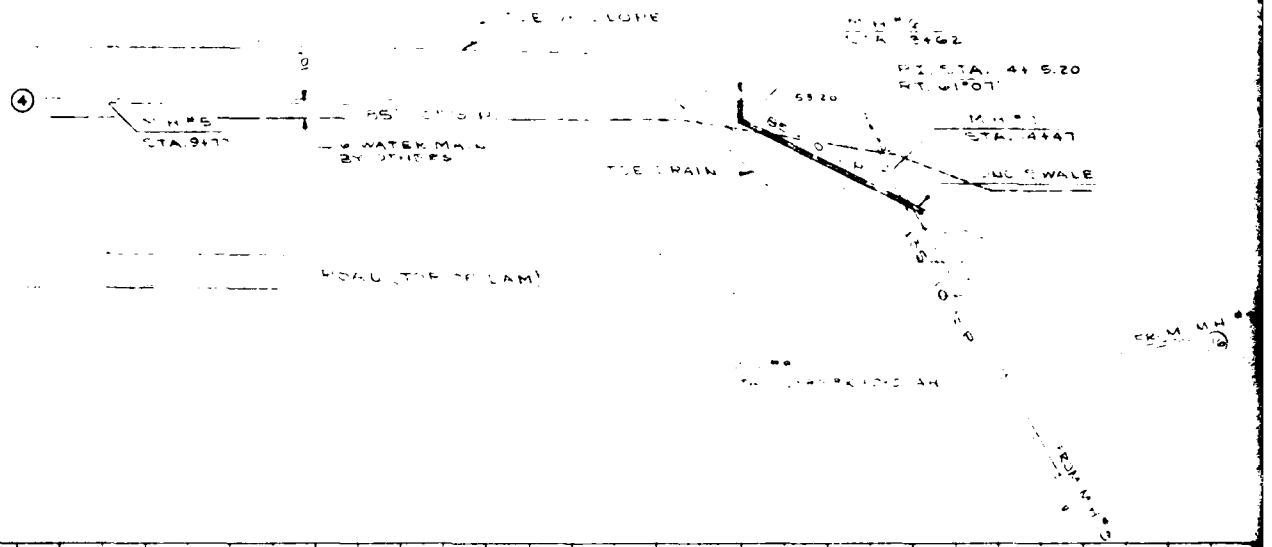


CONC. DRAINAGE STRUCTURE

PROFILE
HORIZONTAL
VERTICAL



SHEET NO. 4
PLATE


STA. 9+77
6" WATER MAIN
BY OTHERS
TOE DRAIN
STA. 4+47
6" WATER MAIN
TOP 352.00
FL. 348.01
TOP 366.00
964.65
348.35
946.85
TOE DRAIN
10+00
11
12
13
14
15
16

PUTNAM COUNTY LAKE
UNIONVILLE

SANITARY S
PLAN AND

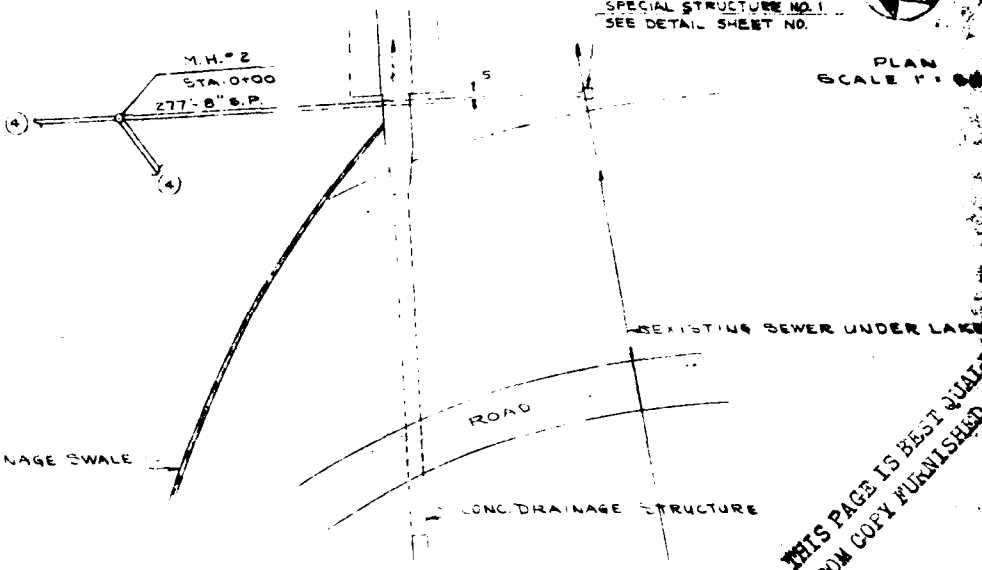
W. H. KLINGNER & ASS
617 BROADWAY

DRAWN	DESIGNED
D.E.H.	W.H.K.

REVISED: 7-18-68 H.K.L.

SPECIAL STRUCTURE NO. 1
SEE DETAIL SHEET NO.

PLAN
SCALE 1"



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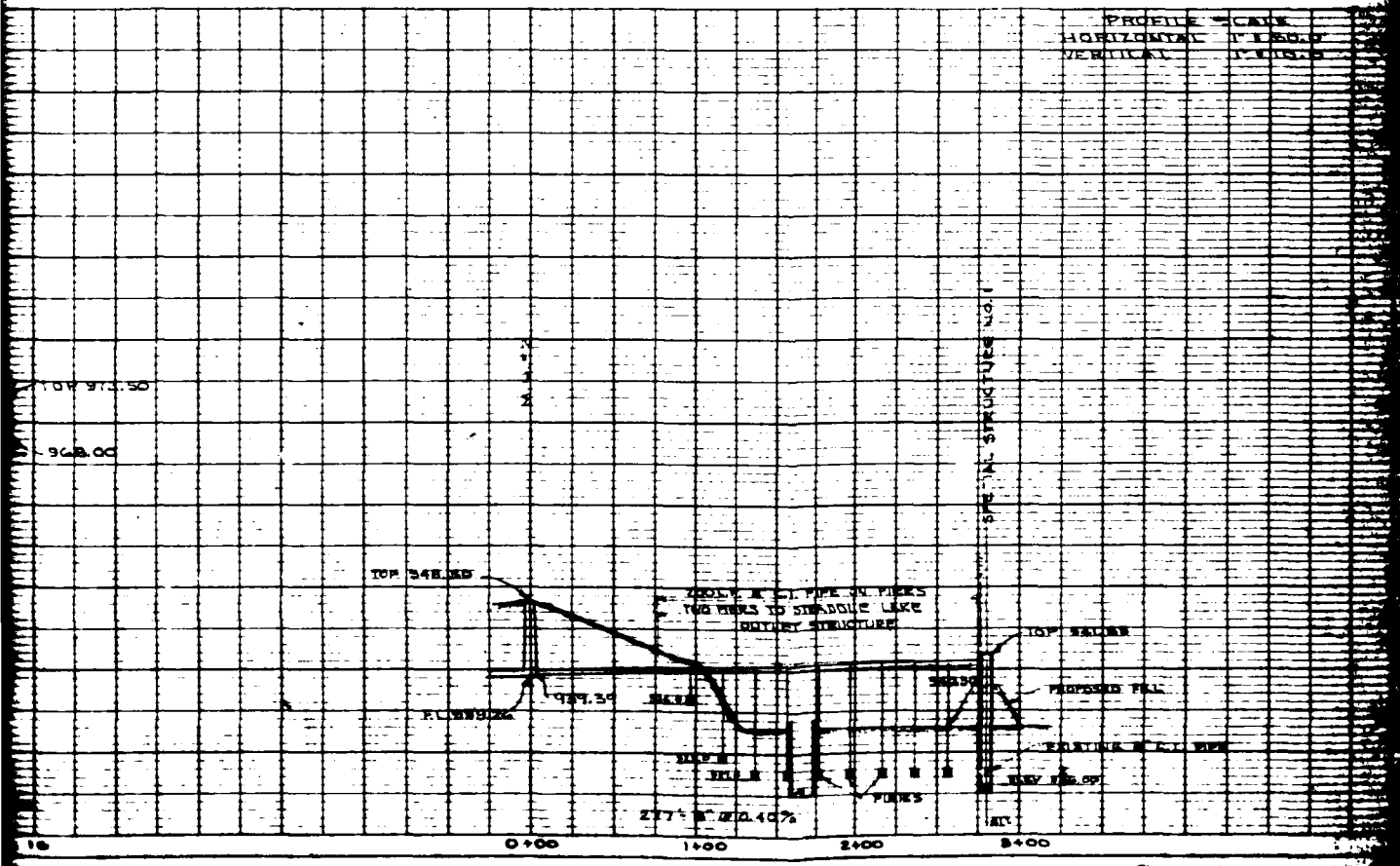
FROM COPY FURNISHED

PROFILE SCALE
HORIZONTAL 1" = 50.0'
VERTICAL 1" = 10.0'



SHEET NO. 8 OF

PLATE C-28

8" C.I. PIPE ON PIERS TO LAGOON

EXIST 8" C.I. PIPE

PROPOSED 8" C.I. PIPE TO LAGOON SEE DETAIL SHEET NO.

EXISTING LAKE OUTLET STRUCTURE

DAM PT.

GENERAL PLAN

EXISTING LAKE INLET STRUCTURE

INVERT ELEV. 92700

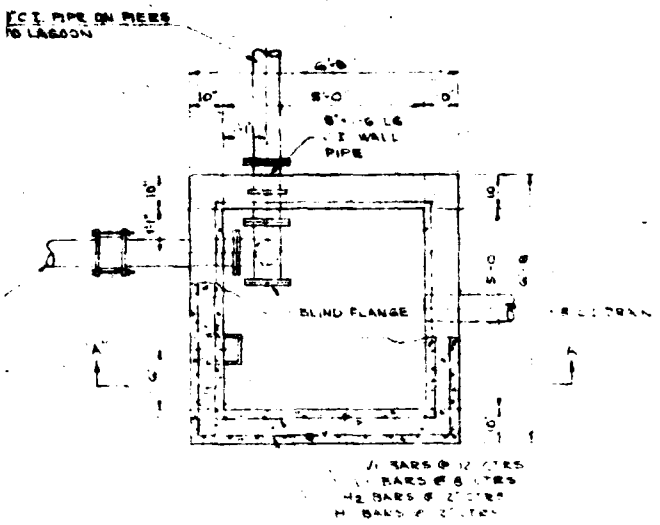
CUT EXISTING 8" C.I. PIPE TWO FEET OUTSIDE PROP. STRUCTURE CONNECT TO A.C.I. PIPE USING A STYLE 38 DRESSER COUPLING

CONCRETE PEDESTA

CONCRETE HEADWALL DETAIL

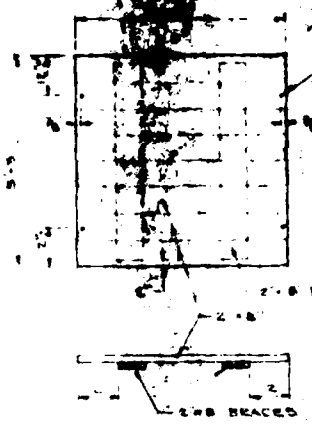
TRENCH WIDTH 12" MIN

SPECIAL



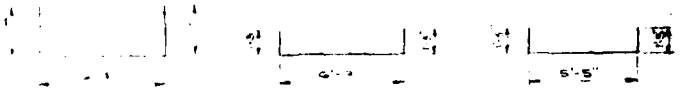
PLAN

SCALE



WOOD COVER

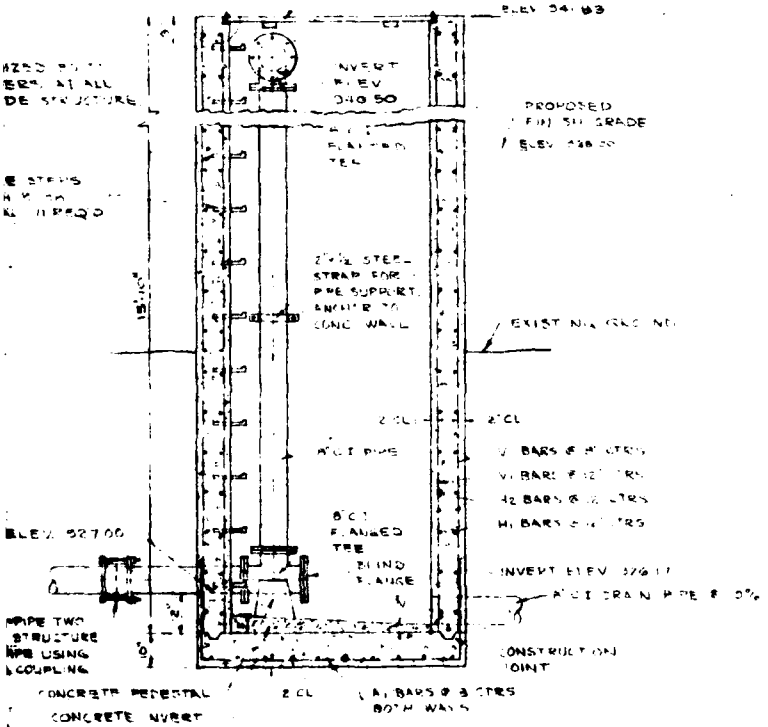
SCALE



BAR DETAILS

BILL OF MATERIAL

REINFORCEMENT BARS			
MARK	NO REQ'D	LENGTH	SIZE
A1	20	11'-4"	#4
H1	64	8'-9"	#4
H2	64	7'-11"	#4
V1	64	15'-8"	#4
REINFORCEMENT BARS			1,534.85
CONCRETE			13.1 CU YDS.



SECTION A-A

SCALE

REVISED: 7-18-68 K.R.L.

PUTNAM COUNTY LAKE ASSOC.
UNIONVILLE, MISSOURI

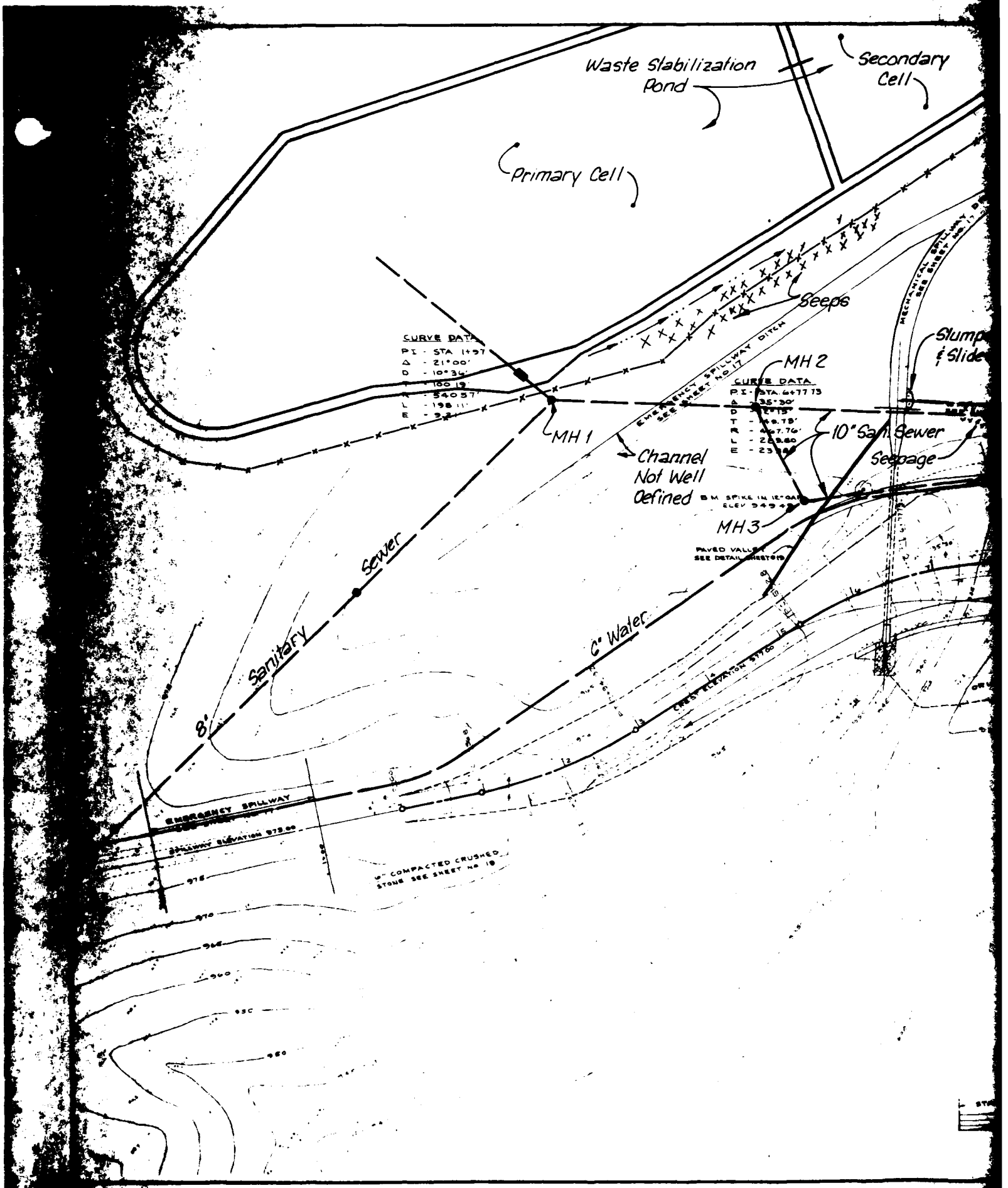
SANITARY SEWER SYSTEM
SPECIAL STRUCTURES NO. I

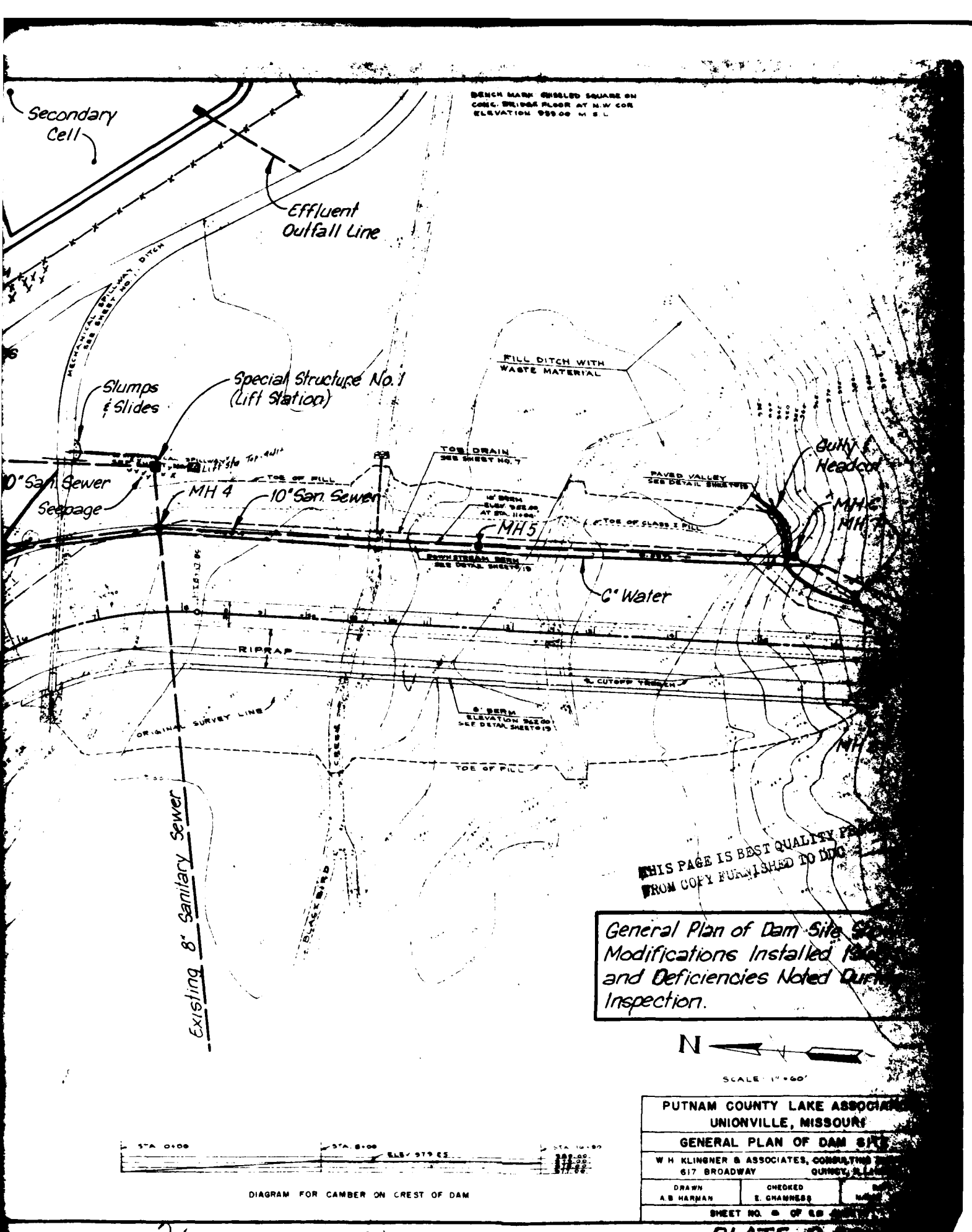
W. H. KLINGNER AND ASSOC.
CONSULTING ENGINEERS QUINCY, ILL.

DESIGNED	DRAWN	CHECKED
W.H.K.		K.R.L.

SHEET

SPECIAL STRUCTURE NO. I


Waste Stabilization Pond
Secondary Cell
Primary Cell
Seeps
Slump & Slide
MH 2
MH 1
MH 3
Channel Not Well Defined
10" San. Sewer
Seepage
8" Sanitary Sewer
6" Water
EMERGENCY SPILLWAY
SPILLWAY ELEVATION 975.00
6" COMPACTED CRUSHED STONE SEE SHEET No 19
CREST ELEVATION 977.00
PAVED VALLEY
SEE DETAIL SHEET 19
EMERGENCY SPILLWAY DITCH
SEE SHEET NO 17
MECHANICAL SPILLWAY
SEE SHEET No 17
CURVE DATA
P.I. - STA. 1+97
Δ - 21°00'
D - 10°34'
T - 180.19'
R - 540.57'
L - 198.11'
E - 32.2'
CURVE DATA
P.I. - STA. 6+77.73
Δ - 35°30'
D - 9°15'
T - 98.75'
R - 487.76'
L - 209.80'
E - 23.
B.M. SPIKE IN 12" OAK
ELEV. 949.4



General Plan of Dam Site Showing Modifications Installed 1966 and Deficiencies Noted During Inspection.

PUTNAM COUNTY LAKE ASSOCIATION
UNIONVILLE, MISSOURI

GENERAL PLAN OF DAM SITE

W. H. KLINGNER & ASSOCIATES, CONSULTING ENGINEERS
617 BROADWAY QUINCY, ILLINOIS

DRAWN	CHECKED	
A.B. HARMAN	E. CHANNESS	

SHEET NO. 12 OF 19 SHEETS

PLATE 12

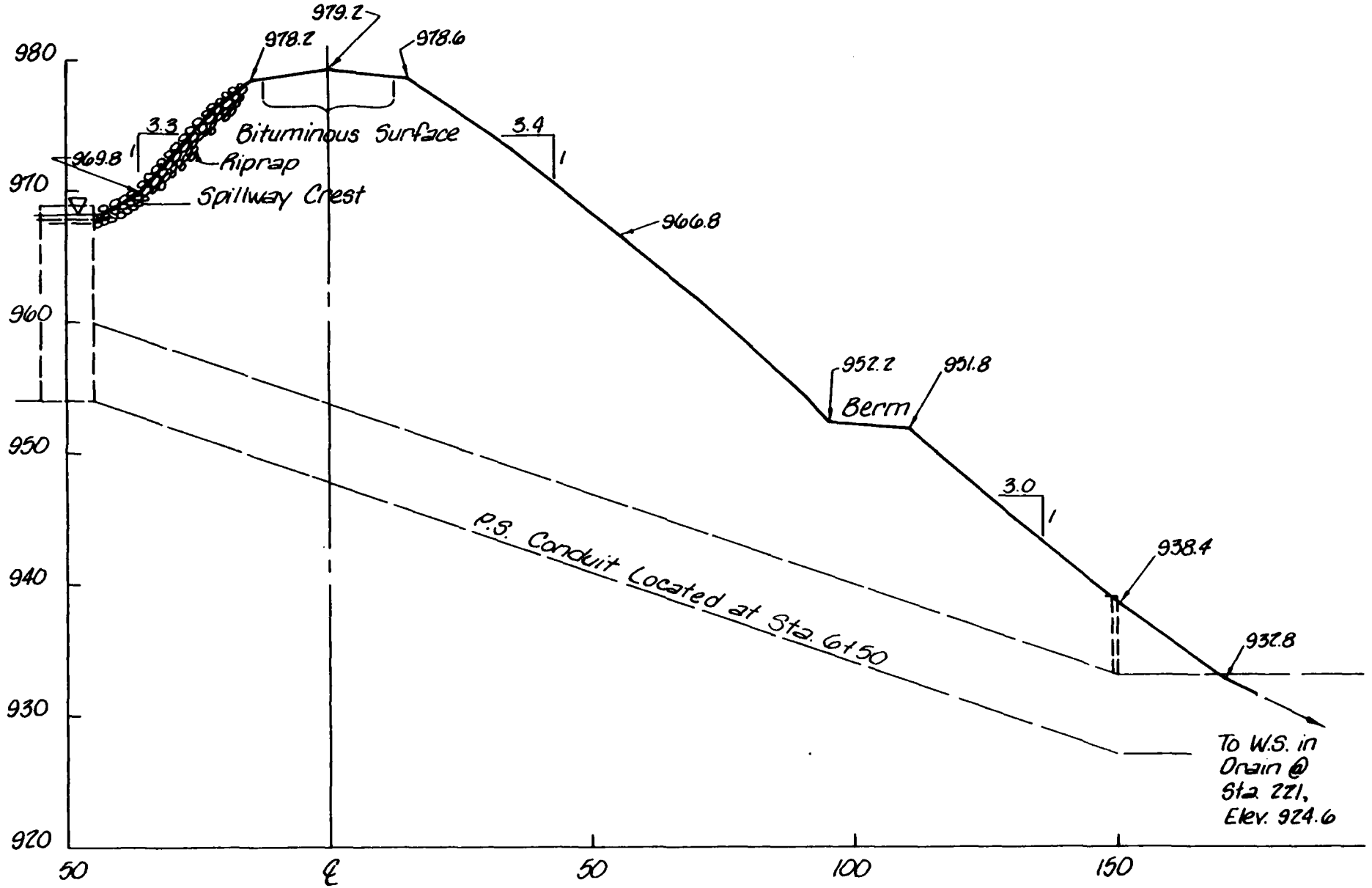
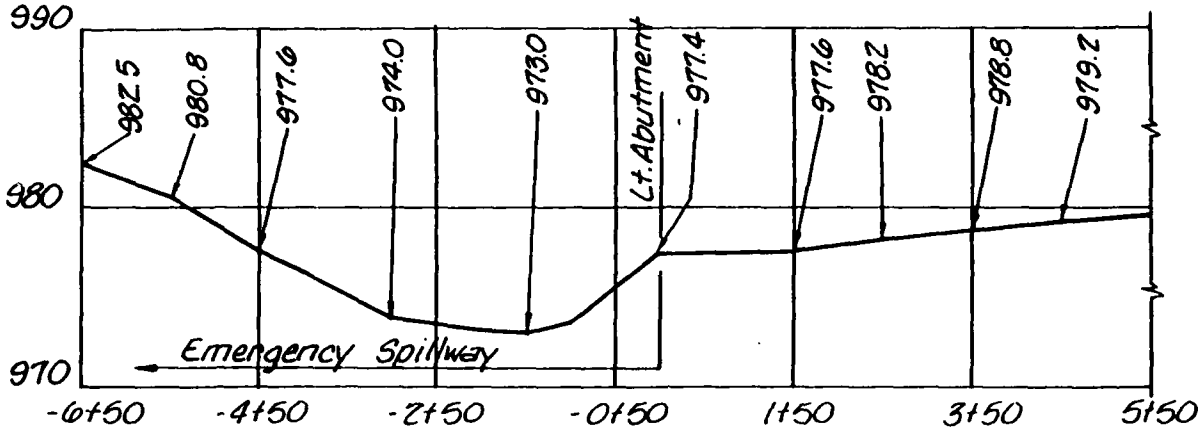


PLATE C-31

MAXIMUM CROSS-SECTION AT STATION 10+00
(As Measured by Inspection Team)
Scale : 1"=25' H, ; 1"=10' V.



CENTERLINE PROFILE ALONG TOP OF DAM

(As Measured by Inspection Team)

Scale: 1" = 200' H

1" = 10' V.

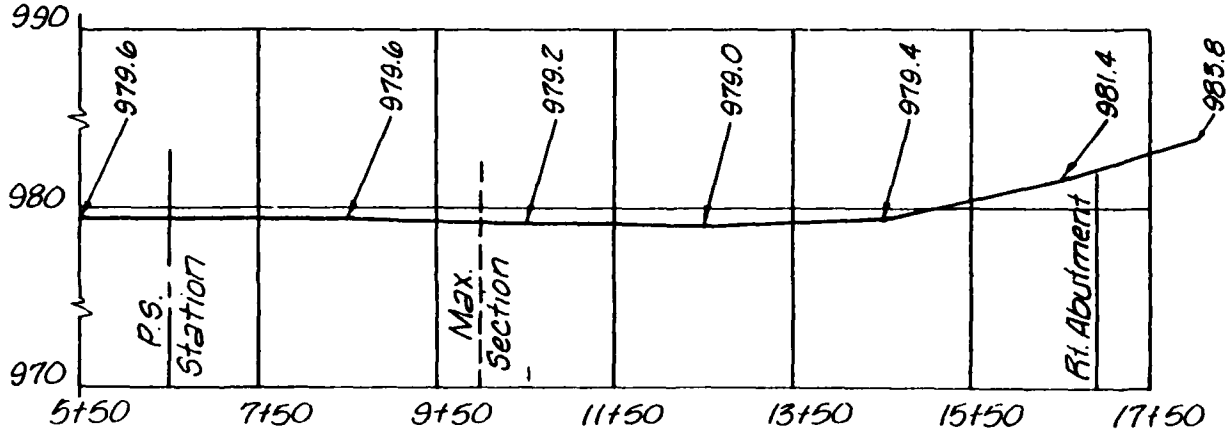
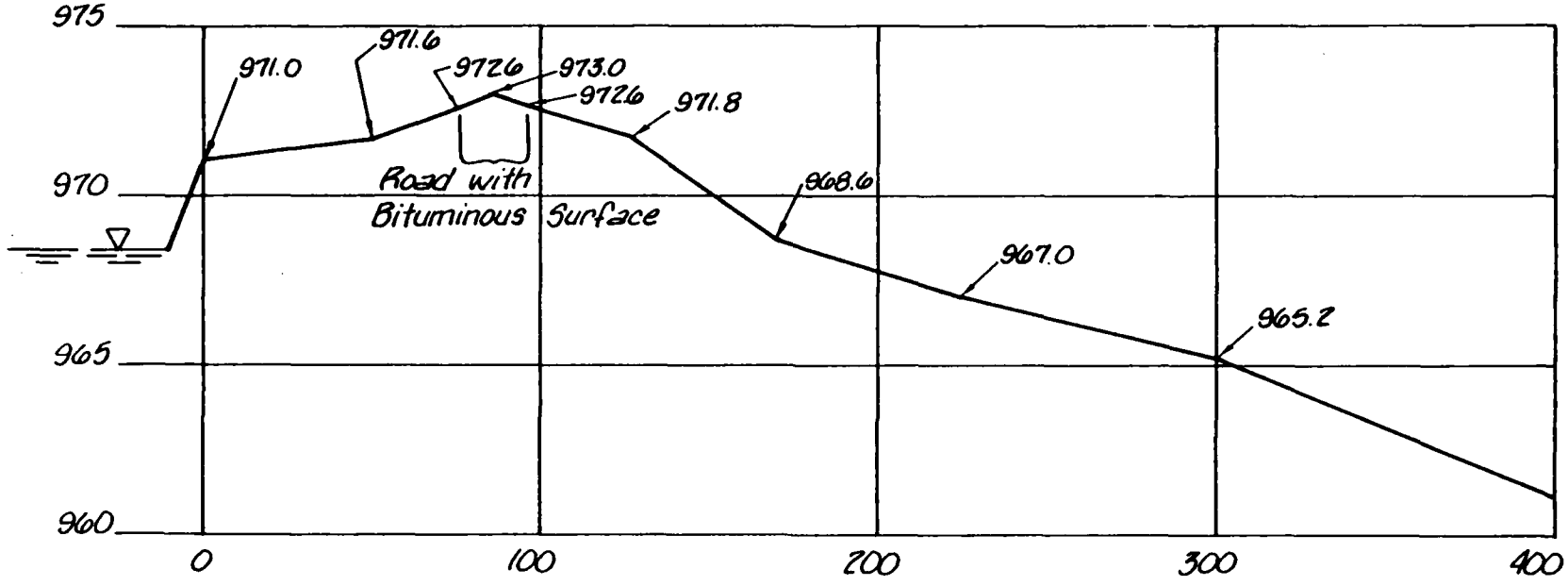


PLATE C-32



PROFILE ALONG EMERGENCY SPILLWAY CENTERLINE
(As Measured by Inspection Team)
Scale : 1" = 50' H
1" = 5' V.

PLATE C-33

APPENDIX D
HYDRAULIC AND HYDROLOGIC DATA

HYDROLOGIC COMPUTATIONS

1. The SCS dimensionless unit hydrograph and the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Corps of Engineers, Davis, California, were used to develop the inflow hydrographs (See this Section).

   a. Forty-eight hour, 1 percent probability rainfall for the dam location was taken from the data for the rainfall station at Kirksville, Mo. as supplied by the St. Louis District, Corps of Engineers per their letter dated 4 March 1980. The forty-eight hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current Corps of Engineers and St. Louis policy and guidance for hydraulics and hydrology.

   b. Drainage area = 24.34 square miles (15,580 acres). Includes area of upstream Unionville City Reservoir (1.4+ sq. mi.).

   c. Time of concentration of runoff = 5.17 hours (computed from "Kirpich" formula, with longest length broken into three sections then totaled).

   d. The antecedent storm conditions for the probable maximum precipitation were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMC III). The antecedent storm conditions for the 1 percent probability precipitation were an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds (SCS AMC II). The initial pool elevation was assumed at the crest of the riser. No antecedent storm was required due to the utilization of the forty-eight hour storm.

   e. The total forty-eight hour storm duration losses for the 1 percent probability storm were 2.26 inches. The total losses for the PMF storm were 1.03 inches. These data are based on SCS runoff curve No. 79 and No. 91 for antecedent moisture conditions SCS AMC II and AMC III respectively. The watershed is composed of primarily SCS hydrologic soil groups, B, C & D. (Seymour (C) - Adair (D) - Shelby (B) soil association). Area is about 80% crops and 20% forested and pasture. Row crops are predominant with very little being contoured or terraced.

   f. Average soil loss rates = 0.05 inch per hour approximately.

2. The discharge ratings for the principal spillway were developed using equations for orifice and weir flow. They are as follows:

a. Orifice flow equation ($Q = CA\sqrt{2gH}$)
where C = orifice coefficient = 0.6 of weir crest, .9 at conduit entrance.
A = area of opening, ft^2 = 121.4
H = total head, ft.

b. Weir flow equation ($Qw = CLH^{1.5}$)
where C = weir coefficient = 3.0 (from SCS Engr. Memo 50)
L = length of weir, ft. = 58.6
H = total head, ft.

The emergency spillway discharge rating was developed using methods for flow over Highway Embankments in U.S.G.S. TWRI, Bk. 3, Ch. A-5 (coefficients based on h/L ratios, paved road surface, and no submergence).

The flows over the dam crest were developed using the HEC-1 (Dam Safety Version) program using the irregular top of dam option.

3. Floods were routed through the reservoir using the HEC-1 (Dam Safety Version) program to determine the capabilities of the spillway and dam embankment crest. A 24-hour PMF storm was first routed through the upstream Unionville City Reservoir dam using data obtained from plans. The upstream dam spillway passed the PMF storm so a breach was not considered necessary for routing through Thunderhead Reservoir. The upstream reservoir was then routed in series using the 48-hour storm. The input, output, and plotted hydrographs are exhibited in this Section.

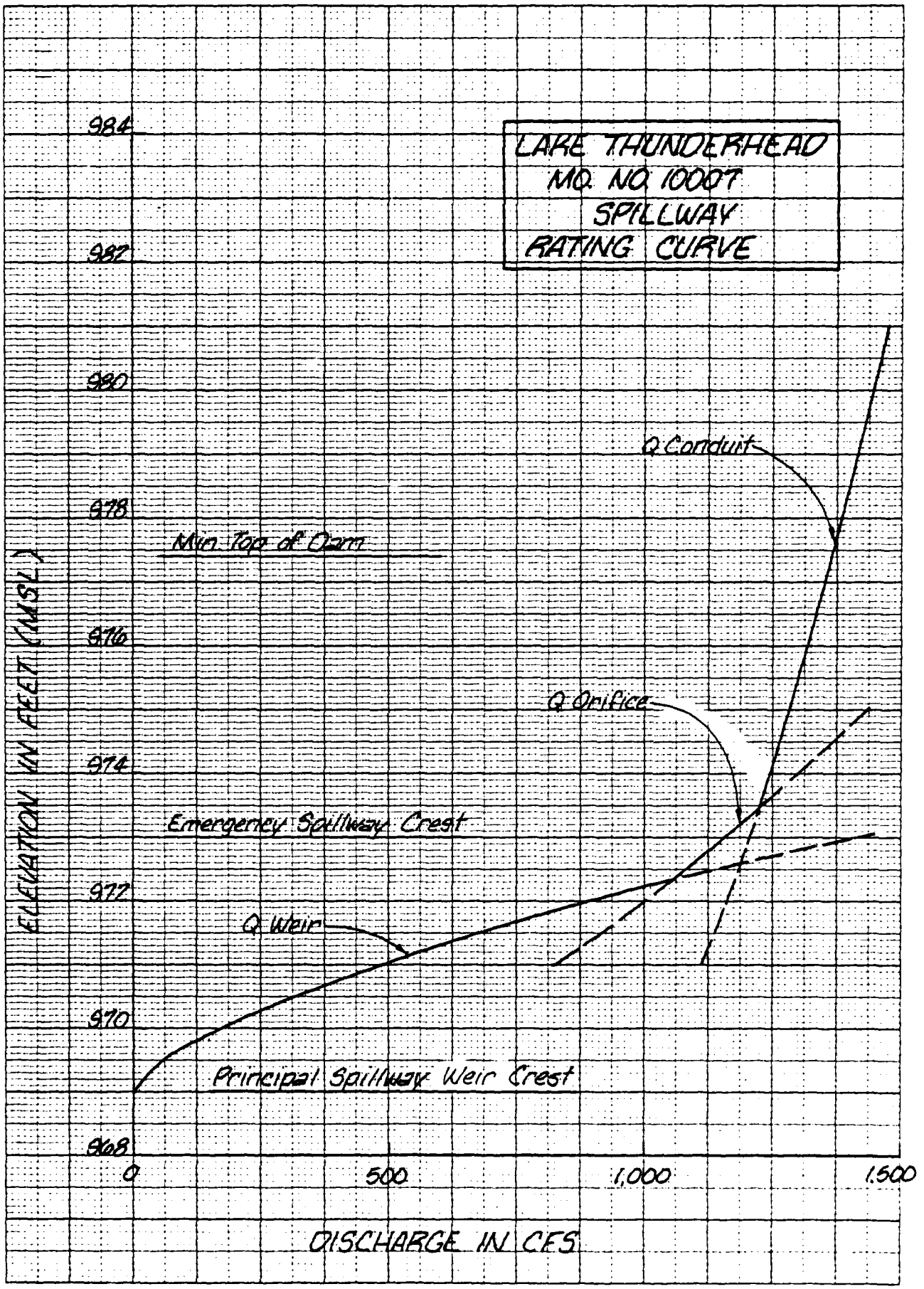

LAKE THUNDERHEAD
MO. NO. 10007
SPILLWAY
RATING CURVE
984
982
980
978
976
974
972
970
968
Q Conduit
Min. Top of Dam
Q Orifice
Emergency Spillway Crest
Q Weir
Principal Spillway Weir Crest
ELEVATION IN FEET (MSL)
0
500
1,000
1,500
DISCHARGE IN CFS

PLATE D-3

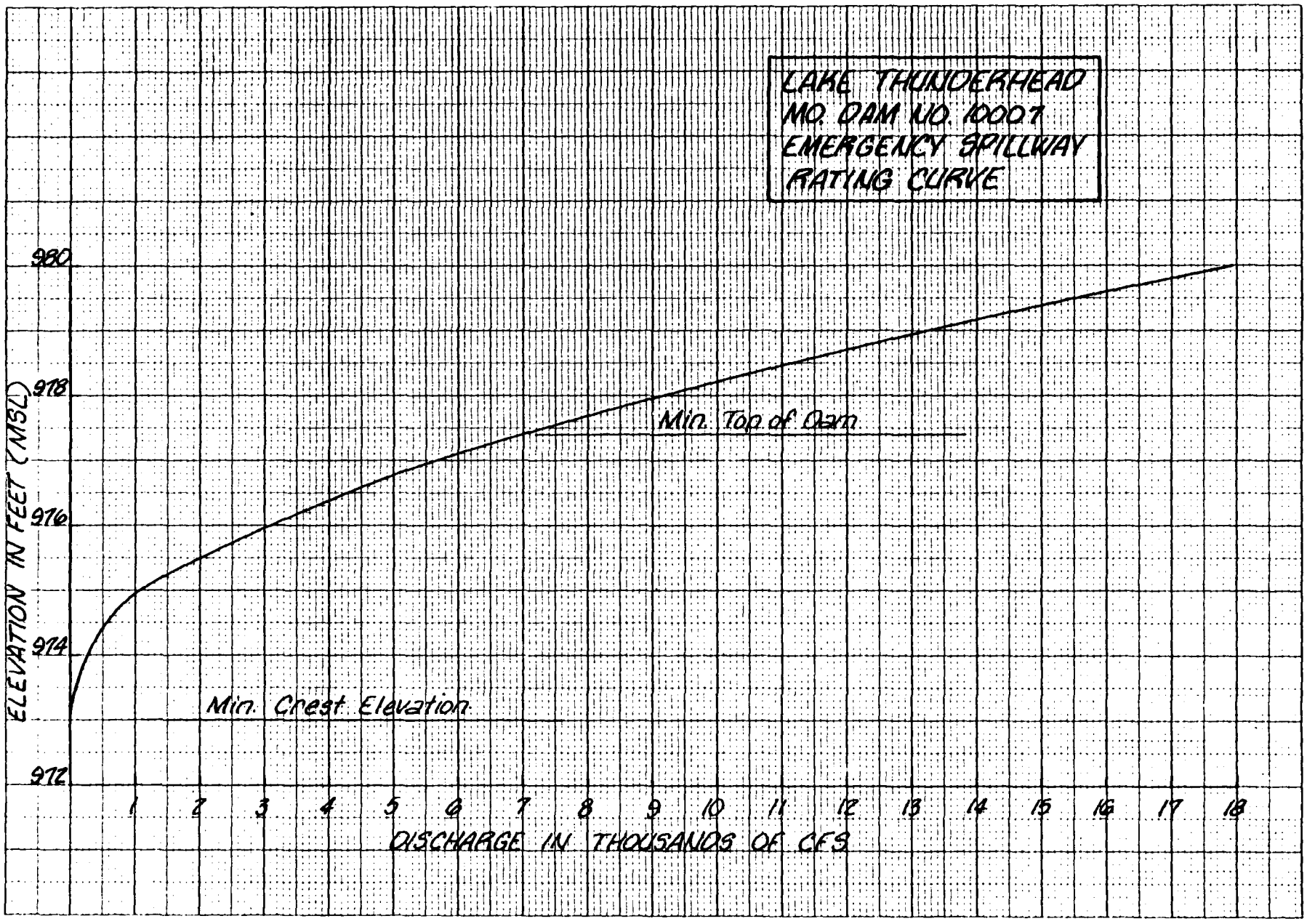


PLATE O-4

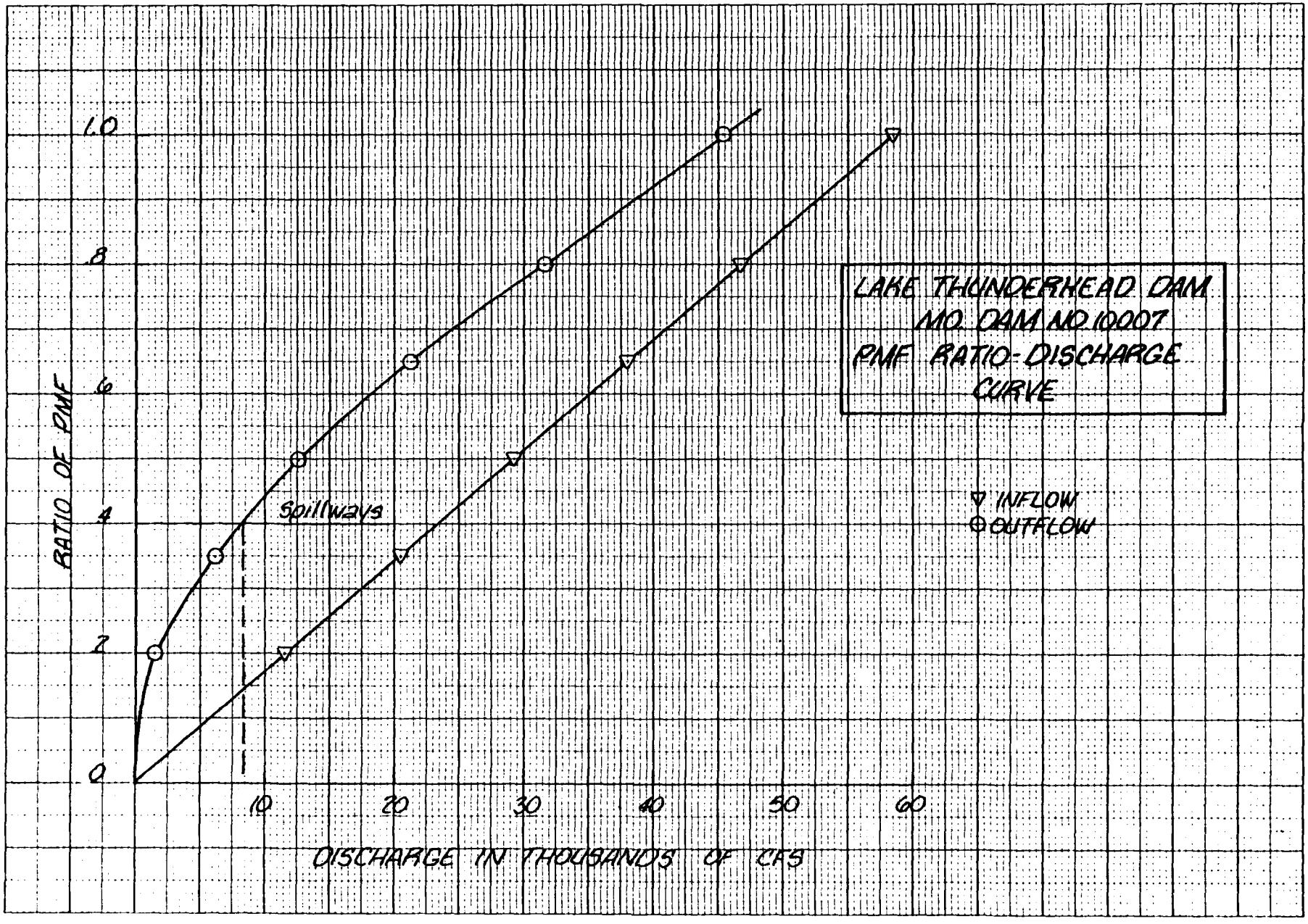


PLATE O-5

```
T1                    ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
T2              H & H   ANALYSIS OF SAFETY OF LAKE THUNDERHEAD DAM-NO 10007
T3      RATIOS OF PMF ROUTED THRU THE RESERVOIR
B     1440000000000000030                                  000000000000000000000003
B1      5
J       100000006000000001
JD    .2000000.3500000.5000000.6500000.8000000001.0
I       000000001                    000000000000000000000001
I1      CALCULATION OF INFLOW HYDRO TO UNIONVILLE CITY RES
M       100000002000001.44           00001.44000001.0                    00000001
P       00000023.70000009300000111000001210000013 1
T                                                          -1.0    -92.0
W1      00000.82
X       0     -.01000000001
I       100000002                    000000020000000000000001
I1      ROUTED FLOWS THRU UNIONVILLE CITY RESERVOIR
Y                          000000010000000 1
Y1      1                                                  -980.0      -1
Y4 980.0    980.7    981.1    983.0    984.7    989.5    992.5   1000.0
Y5      0       50      100      500     1000     3000     4500     9500
$3      0000001.2000015.3000072.8000002020000040800000749000008380000093800001040
$5  208000004240
$E    952000009550000096000000965000009700000097500000980000009810000098200000983
$E    990000001000
$$    980
$D    993000002.8000001.500000650
I       000000003                    000000000000000000000001
I1      CALCULATION OF INFLOW HYDRO TO RES NO 10007
M       100000002000022.91           00022.91000001.0                    00000001
P       00000023.70000009300000111000001210000013 1
T                                                          -1.0    -91.0
W2      00003.10
X       0     -.01000000001
I       2 SUM 2+3                    000000020000000000000001
I1      COMBINED INFLOW HYDROGRAPH TO RESERVOIR 10007
I       100000004                    000000020000000000000001
I1      ROUTED FLOWS THRU RESERVOIR NO 10007
Y                          000000010000000 1
Y1      1                                                  -969.0      -1
Y4 969.0000969.5000970.0000971.0000972.0000972.3000973.0000973.4000974.0000975.0
Y4 976.0000977.4000978.0000980.0
Y5      000000062000001760000049700000215000010500000011700000131000001550000023 40
Y5  44200000827000010400000019400
$1      000000062000000190000003600000072000000858000009200000011100000124000001370
$$  14900000141000001745
W       0.0000950.0000960.0000970.0000976.0000978.0000980.0000982.0000984.0
W1      0.0000988.0000990.0
W4      0.0
```

Note: Content of this plate from this entry repeated on Plate D-7

PLATE D-6

```
X        0     -.01000000001
I        100000002                    00000000200000000000000001
I1        ROUTED FLOWS THRU UNIONVILLE CITY RESERVOIR
Y                              00000001000000001
Y1        1                                                  -980.0       -1
Y4 980.0    980.7    981.1    983.0    984.7    989.5    992.5   1000.0
Y5        0       50      100      500     1000     3000     4500     9500
$S        0000001.2000015.3000079.800000202000004080000074900000838000009330000104O
$S  20800000424O
$E   952000009550000096000000965000009700000097500000980000009810000098200000983
$E   990000001000
$$   980
$D   9930000002.80000001.5000000650
I         000000003                    00000000000000000000000001
I1        CALCULATION OF INFLOW HYDRO TO RES NO 10007
M         10000000200022.91            00022.91000001.0                        00000001
F        0000023.70000009300000111000001210000013l
T                                                              -1.0    -91.0
W2        00003.10
X        0     -.01000000001
I        2 SUM 2+3                    00000002000000000000000001
I1        COMBINED INFLOW HYDROGRAPH TO RESERVOIR 10007
I        100000004                    00000002000000000000000001
I1        ROUTED FLOWS THRU RESERVOIR NO 10007
Y                              00000001000000001
Y1        1                                                  -969.0       -1
Y4 969.0000969.5000970.0000971.0000972.0000972.3000973.0000973.4000974.0000975.0
Y4 976.0000977.4000978.0000980.0
Y5        000000062000000176000004970000091500001050000011700000131000001550000002340
Y5  44600000827000010400000019400
$A        000000060000001900000036000000620000006580000099000001110000012400000137O
$A  14900000161000001745
$E 923.5000930.0000940.0000950.0000960.0000966.0000968.0000970.0000972.0000974.0
$E 976.0000978.0000980.0
$$    969
$D 977.4000003.0000001.5000001550
$L        000000050000002000000035000000400000006500000115000001520
$V 977.4000977.6000978.0000978.8000979.0000979.2000979.6000980.0
F       99
A
A
A
A
A
```

PLATE D-7

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	000001
ROUTE HYDROGRAPH TO	000002
RUNOFF HYDROGRAPH AT	000003
COMBINE 2 HYDROGRAPHS AT UM 243	
ROUTE HYDROGRAPH TO	000004
END OF NETWORK	

PLATE D-8

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

RUN DATE= 80/06/18.
TIME= 14.02.48.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
H & H ANALYSIS OF SAFETY OF LAKE THUNDERHEAD DAM-NO 10007
RATIOS OF PMF ROUTED THRU THE RESERVOIR

JOB SPECIFICATION

NU	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
144	0	30	0	0	0	0	0	3	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1
RTIOS= .20 .35 .50 .65 .80 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF INFLOW HYDRO TO UNIONVILLE CITY RES

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000001	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDR	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	1.44	0.00	1.44	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.70	93.00	111.00	121.00	131.00	0.00	0.00

LOSS DATA

LROPT	STRTR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-92.00	0.00	0.00

CURVE NO = -92.00 WETNESS = -1.00 EFFECT CN = 92.00

UNIT HYDROGRAPH DATA
TP= 0.00 LAG= .82

RECESSION DATA
STRTQ= 0.00 QRCSN= .01 RTIOR= 1.00

TIME INCREMENT TOO LARGE (MUST BE .LT. LAG/2)

UNIT HYDROGRAPH 10 END OF PERIOD ORDINATES, TP= 0.00 HOURS, LAG= .82 VOL= 1.00
[illegible] 50%. [illegible] 100. 50. 24. 11. 4. [illegible]

PLATE D-9

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.30	1	.01	0.00	.01	0.	1.02	12.30	73	1.10	1.09	.01	854.
1.01	1.00	2	.01	0.00	.01	0.	1.02	13.00	74	1.10	1.09	.01	1315.
1.01	1.30	3	.01	0.00	.01	0.	1.02	13.30	75	1.32	1.31	.01	1773.
1.01	2.00	4	.01	0.00	.01	0.	1.02	14.00	76	1.32	1.32	.01	2084.
1.01	2.30	5	.01	0.00	.01	0.	1.02	14.30	77	1.65	1.65	.01	2370.
1.01	3.00	6	.01	0.00	.01	0.	1.02	15.00	78	1.65	1.65	.01	2673.
1.01	3.30	7	.01	0.00	.01	0.	1.02	15.30	79	2.01	2.01	.01	2981.
1.01	4.00	8	.01	0.00	.01	0.	1.02	16.00	80	6.37	6.35	.01	4494.
1.01	4.30	9	.01	0.00	.01	0.	1.02	16.30	81	1.54	1.54	.00	6230.
1.01	5.00	10	.01	0.00	.01	0.	1.02	17.00	82	1.54	1.54	.00	5420.
1.01	5.30	11	.01	0.00	.01	0.	1.02	17.30	83	1.21	1.21	.00	3972.
1.01	6.00	12	.01	0.00	.01	0.	1.02	18.00	84	1.21	1.21	.00	3104.
1.01	6.30	13	.03	0.00	.03	0.	1.02	18.30	85	.12	.12	.00	2346.
1.01	7.00	14	.03	0.00	.03	0.	1.02	19.00	86	.12	.12	.00	1429.
1.01	7.30	15	.03	0.00	.03	0.	1.02	19.30	87	.12	.12	.00	774.
1.01	8.00	16	.03	.00	.03	0.	1.02	20.00	88	.12	.12	.00	481.
1.01	8.30	17	.03	.00	.03	1.	1.02	20.30	89	.12	.12	.00	337.
1.01	9.00	18	.03	.00	.03	3.	1.02	21.00	90	.12	.12	.00	269.
1.01	9.30	19	.03	.01	.02	5.	1.02	21.30	91	.12	.12	.00	241.
1.01	10.00	20	.03	.01	.02	8.	1.02	22.00	92	.12	.12	.00	228.
1.01	10.30	21	.03	.01	.02	11.	1.02	22.30	93	.12	.12	.00	222.
1.01	11.00	22	.03	.01	.02	13.	1.02	23.00	94	.12	.12	.00	220.
1.01	11.30	23	.03	.01	.02	15.	1.02	23.30	95	.12	.12	.00	220.
1.01	12.00	24	.03	.01	.02	18.	1.03	0.00	96	.12	.12	.00	220.
1.01	12.30	25	.09	.04	.05	27.	1.03	.30	97	0.00	0.00	0.00	188.
1.01	13.00	26	.09	.05	.04	49.	1.03	1.00	98	0.00	0.00	0.00	111.
1.01	13.30	27	.11	.06	.04	74.	1.03	1.30	99	0.00	0.00	0.00	62.
1.01	14.00	28	.11	.07	.04	97.	1.03	2.00	100	0.00	0.00	0.00	62.
1.01	14.30	29	.14	.10	.04	122.	1.03	2.30	101	0.00	0.00	0.00	62.
1.01	15.00	30	.14	.10	.03	149.	1.03	3.00	102	0.00	0.00	0.00	62.
1.01	15.30	31	.17	.13	.04	177.	1.03	3.30	103	0.00	0.00	0.00	62.
1.01	16.00	32	.53	.44	.08	292.	1.03	4.00	104	0.00	0.00	0.00	62.
1.01	16.30	33	.13	.11	.01	425.	1.03	4.30	105	0.00	0.00	0.00	62.
1.01	17.00	34	.13	.11	.01	379.	1.03	5.00	106	0.00	0.00	0.00	62.
1.01	17.30	35	.10	.09	.01	280.	1.03	5.30	107	0.00	0.00	0.00	62.
1.01	18.00	36	.10	.09	.01	226.	1.03	6.00	108	0.00	0.00	0.00	62.
1.01	18.30	37	.01	.01	.00	173.	1.03	6.30	109	0.00	0.00	0.00	62.
1.01	19.00	38	.01	.01	.00	106.	1.03	7.00	110	0.00	0.00	0.00	62.
1.01	19.30	39	.01	.01	.00	58.	1.03	7.30	111	0.00	0.00	0.00	62.
1.01	20.00	40	.01	.01	.00	36.	1.03	8.00	112	0.00	0.00	0.00	62.
1.01	20.30	41	.01	.01	.00	25.	1.03	8.30	113	0.00	0.00	0.00	62.
1.01	21.00	42	.01	.01	.00	20.	1.03	9.00	114	0.00	0.00	0.00	62.
1.01	21.30	43	.01	.01	.00	18.	1.03	9.30	115	0.00	0.00	0.00	62.
1.01	22.00	44	.01	.01	.00	17.	1.03	10.00	116	0.00	0.00	0.00	62.
1.01	22.30	45	.01	.01	.00	17.	1.03	10.30	117	0.00	0.00	0.00	62.
1.01	23.00	46	.01	.01	.00	17.	1.03	11.00	118	0.00	0.00	0.00	62.
1.01	23.30	47	.01	.01	.00	17.	1.03	11.30	119	0.00	0.00	0.00	62.
1.02	0.00	48	.01	.01	.00	17.	1.03	12.00	120	0.00	0.00	0.00	62.
1.02	.30	49	.08	.07	.01	34.	1.03	12.30	121	0.00	0.00	0.00	62.
1.02	1.00	50	.08	.07	.01	76.	1.03	13.00	122	0.00	0.00	0.00	62.
1.02	1.30	51	.08	.07	.01	108.	1.03	13.30	123	0.00	0.00	0.00	62.
1.02	2.00	52	.08	.07	.01	125.	1.03	14.00	124	0.00	0.00	0.00	62.
1.02	2.30	53	.08	.07	.01	131.	1.03	14.30	125	0.00	0.00	0.00	62.
1.02	3.00	54	.08	.07	.00	134.	1.03	15.00	126	0.00	0.00	0.00	62.
1.02	3.30	55	.08	.07	.00	136.	1.03	15.30	127	0.00	0.00	0.00	62.
1.02	4.00	56	.08	.07	.00	137.	1.03	16.00	128	0.00	0.00	0.00	62.
1.02	4.30	57	.08	.07	.00	138.	1.03	16.30	129	0.00	0.00	0.00	62.
1.02	5.00	58	.08	.07	.00	139.	1.03	17.00	130	0.00	0.00	0.00	62.
1.02	5.30	59	.08	.08	.00	139.	1.03	17.30	131	0.00	0.00	0.00	62.

PLATE D-10

1.02	6.00	60	.08	.08	.00	139.	1.03	18.00	132	0.00	0.00	0.00	62.
1.02	6.30	61	.36	.34	.02	212.	1.03	18.30	133	0.00	0.00	0.00	62.
1.02	7.00	62	.36	.34	.01	384.	1.03	19.00	134	0.00	0.00	0.00	62.
1.02	7.30	63	.36	.34	.01	521.	1.03	19.30	135	0.00	0.00	0.00	62.
1.02	8.00	64	.36	.35	.01	584.	1.03	20.00	136	0.00	0.00	0.00	62.
1.02	8.30	65	.36	.35	.01	616.	1.03	20.30	137	0.00	0.00	0.00	62.
1.02	9.00	66	.36	.35	.01	631.	1.03	21.00	138	0.00	0.00	0.00	62.
1.02	9.30	67	.36	.35	.01	640.	1.03	21.30	139	0.00	0.00	0.00	62.
1.02	10.00	68	.36	.35	.01	644.	1.03	22.00	140	0.00	0.00	0.00	62.
1.02	10.30	69	.36	.35	.01	647.	1.03	22.30	141	0.00	0.00	0.00	62.
1.02	11.00	70	.36	.35	.00	649.	1.03	23.00	142	0.00	0.00	0.00	62.
1.02	11.30	71	.36	.35	.00	650.	1.03	23.30	143	0.00	0.00	0.00	62.
1.02	12.00	72	.36	.35	.00	651.	1.04	0.00	144	0.00	0.00	0.00	62.
									SUM	31.05	30.03	1.02	58547.
										(789.)	(763.)	(26.)	(1657.58)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6230.	3232.	1097.	406.	58520.
CMS	176.	92.	31.	12.	1657.
INCHES		20.88	28.35	31.50	31.50
MM		530.29	720.12	800.17	800.17
AC-FT		1603.	2176.	2418.	2418.
THOUS CU M		1977.	2684.	2983.	2983.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1246.	646.	219.	81.	11704.
CMS	35.	18.	6.	2.	331.
INCHES		4.18	5.67	6.30	6.30
MM		106.06	144.02	160.03	160.03
AC-FT		321.	435.	484.	484.
THOUS CU M		395.	537.	597.	597.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2181.	1131.	384.	142.	20482.
CMS	62.	32.	11.	4.	580.
INCHES		7.31	9.92	11.03	11.03
MM		185.60	252.04	280.06	280.06
AC-FT		561.	762.	846.	846.
THOUS CU M		692.	940.	1044.	1044.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 3 [1/2 PMF]

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3117.	1616.	549.	203.	29260.
CMS	88.	46.	16.	6.	829.
INCHES		10.44	14.18	15.75	15.75
MM		265.14	360.06	400.08	400.08
AC-FT		802.	1088.	1209.	1209.
THOUS CU M		989.	1343.	1492.	1492.

HYDROGRAPH AT STA0000001 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4050.	2101.	713.	264.	38038.
CMS	115.	59.	20.	7.	1077.
INCHES		13.57	18.43	20.48	20.48
MM		344.69	468.08	520.11	520.11
AC-FT		1040.	1415.	1572.	1572.
THOUS CU M		1.283.	1745.	1939.	1939.

HYDROGRAPH AT STA0000001 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4984.	2585.	878.	325.	46816.
CMS	141.	73.	25.	9.	1326.
INCHES		16.70	22.68	25.20	25.20
MM		424.29	576.10	640.14	640.14
AC-FT		1282.	1741.	1935.	1935.
THOUS CU M		1581.	2147.	2386.	2386.

HYDROGRAPH AT STA0000001 FOR PLAN 1, RTIO 6 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	6230.	3232.	1097.	406.	58570.
CMS	176.	92.	31.	12.	1657.
INCHES		20.88	28.35	31.50	31.50
MM		530.29	720.12	800.17	800.17
AC-FT		1603.	2176.	2418.	2418.
THOUS CU M		1977.	2684.	2983.	2983.

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HYDROGRAPH ROUTING

ROUTED FLOWS THRU UNIONVILLE CITY RESERVOIR

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000002	1	0	0	2	0	1	0	0

ROUTING DATA

CLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IETA		LSTR
0.0	0.000	0.000	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ITYPRAT
1	0	0	0.000	0.000	0.000	0.000	1

ELEV	930.00	930.20	931.10	933.00	934.20	939.50	942.50	1000.00	
STOR	0.00	40.00	100.00	400.00	1000.00	3000.00	4500.00	9500.00	
OUTFLOW CFS	0.	1.	15.	30.	105.	405.	745.	933.	1040.
	0.	42.	425.	850.	2974.	11469.	21099.	26420.	29451.
TIME HOURS	0.	24.	48.	72.	120.	216.	288.	384.	480.

PLATE D-12

990. 1000.

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
980.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
993.0	2.8	1.5	650.

~~STATION 000002, PLAN 1, RATIO 1~~

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	1.	1.	2.	2.	3.
4.	5.	8.	10.	12.	13.	14.	14.	14.	14.
14.	14.	13.	13.	13.	12.	12.	12.	12.	12.
12.	12.	13.	13.	14.	14.	14.	15.	15.	16.
16.	18.	20.	23.	26.	29.	33.	36.	39.	42.
45.	47.	51.	61.	75.	92.	118.	152.	188.	237.
303.	375.	418.	441.	449.	444.	426.	403.	378.	353.
329.	307.	286.	265.	246.	228.	212.	196.	180.	166.
152.	140.	129.	119.	109.	101.	96.	91.	87.	83.
79.	75.	72.	69.	65.	62.	60.	57.	54.	52.
50.	49.	48.	46.	45.	44.	43.	42.	41.	40.
39.	38.	38.	37.	36.	35.	35.	34.	33.	32.
32.	31.	31.	30.						

STORAGE

749.	749.	749.	749.	749.	749.	749.	749.	749.	749.
749.	749.	749.	749.	749.	749.	749.	749.	749.	749.
749.	749.	749.	750.	750.	750.	750.	751.	752.	753.
754.	756.	759.	761.	764.	765.	766.	767.	767.	767.
767.	766.	766.	765.	765.	765.	764.	764.	764.	764.
764.	764.	765.	765.	766.	766.	767.	768.	768.	769.
768.	771.	774.	778.	782.	786.	790.	794.	797.	801.
805.	808.	812.	819.	829.	841.	856.	871.	887.	909.
942.	976.	999.	1010.	1014.	1011.	1002.	991.	978.	965.
953.	942.	932.	922.	913.	905.	898.	891.	884.	877.
871.	866.	861.	856.	852.	848.	844.	841.	838.	835.
832.	829.	827.	824.	822.	820.	818.	816.	814.	813.
811.	810.	808.	807.	805.	804.	803.	802.	800.	799.
798.	797.	796.	795.	794.	793.	792.	791.	790.	789.
788.	788.	787.	786.						

STAGE

980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0
980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0
980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0
980.1	980.1	980.1	980.1	980.2	980.2	980.2	980.2	980.2	980.2
[illegible]	980.2	980.2	980.2	980.2	980.2	980.2	980.2	980.2	980.2
980.2	980.2	980.2	980.2	980.2	980.2	980.2	980.2	980.2	980.2
980.3	980.3	980.3	980.3	980.4	980.4	980.5	980.5	980.5	980.6
[illegible]	980.7	980.7	980.8	980.9	981.0	981.2	981.3	981.5	981.8
982.1	982.4	982.6	982.7	982.8	982.7	982.6	982.5	982.4	982.3
982.2	982.1	982.0	981.9	981.8	981.7	981.6	981.6	981.5	981.4
981.3	981.3	981.2	981.2	981.1	981.1	981.1	981.1	981.0	981.0
980.9	980.9	980.9	980.8	980.8	980.8	980.8	980.8	980.7	980.7
[illegible]	980.7	980.7	980.7	980.6	980.6	980.6	980.6	980.6	980.6
0.	980.5	980.5	980.5	980.5	980.5	980.5	980.5	980.5	980.5

IVN

STATION 000002, PLAN 1, RATIO 3 [1/2 PMF]

END OF PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	1.	1.	2.	3.	4.	6.	8.
10.	14.	19.	25.	30.	33.	35.	36.	36.	36.
35.	34.	34.	33.	32.	31.	30.	30.	29.	29.
30.	31.	32.	33.	34.	35.	36.	37.	38.	39.
41.	44.	50.	63.	77.	90.	103.	122.	140.	156.
171.	184.	201.	231.	279.	334.	395.	462.	537.	641.
802.	968.	1105.	1176.	1197.	1169.	1101.	1015.	947.	885.
825.	769.	718.	670.	626.	586.	548.	510.	474.	439.
407.	378.	351.	328.	303.	281.	259.	239.	221.	204.
189.	175.	163.	151.	141.	131.	122.	114.	107.	100.
97.	93.	90.	87.	84.	81.	78.	75.	73.	70.
68.	66.	64.	62.	61.	59.	57.	56.	54.	53.
52.	51.	50.	49.						

STORAGE

749.	749.	749.	749.	749.	749.	749.	749.	749.	749.
749.	749.	749.	749.	749.	749.	749.	749.	749.	749.
749.	750.	750.	750.	751.	751.	753.	754.	756.	759.
762.	766.	773.	780.	786.	790.	793.	794.	794.	794.
793.	792.	791.	790.	789.	788.	787.	786.	785.	785.
786.	787.	788.	790.	791.	793.	794.	795.	797.	798.
800.	804.	812.	821.	830.	840.	849.	857.	865.	873.
879.	885.	893.	907.	928.	955.	986.	1021.	1059.	1111.
1177.	1276.	1330.	1355.	1363.	1353.	1329.	1298.	1266.	1234.
1204.	1176.	1150.	1126.	1104.	1083.	1064.	1045.	1027.	1009.
993.	978.	964.	951.	940.	929.	919.	910.	902.	894.
887.	881.	876.	871.	866.	862.	858.	854.	851.	848.
845.	842.	840.	837.	835.	833.	831.	829.	828.	826.
824.	823.	821.	820.	819.	818.	817.	815.	815.	814.
813.	812.	811.	810.						

STAGE

980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0
980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0
980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.1	980.1	980.1
980.1	980.2	980.3	980.4	980.4	980.5	980.5	980.5	980.5	980.5
980.5	980.5	980.5	980.5	980.4	980.4	980.4	980.4	980.4	980.4
980.4	980.4	980.4	980.5	980.5	980.5	980.5	980.5	980.5	980.5
980.5	980.6	980.7	980.8	980.9	981.0	981.1	981.2	981.3	981.4
981.4	981.5	981.6	981.7	981.9	982.2	982.5	982.8	983.1	983.5
984.0	984.6	985.0	984.1	984.2	985.1	984.9	984.7	984.5	984.3
984.1	983.9	983.7	983.6	983.4	983.3	983.2	983.0	982.9	982.7
982.5	982.4	982.3	982.2	982.1	982.0	981.9	981.8	981.7	981.6
981.5	981.5	981.4	981.3	981.3	981.2	981.2	981.2	981.1	981.1
981.1	981.0	981.0	981.0	981.0	980.9	980.9	980.9	980.9	980.9
980.8	980.8	980.8	980.8	980.8	980.8	980.8	980.7	980.7	980.7
980.7	980.7	980.7	980.7						

PEAK OUTFLOW IS 1176. AT TIME 42.50 HOURS.

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
1176.	1104.	904.	673.	222231.

PLATE D-14

CMS	34.	28.	14.	5.	787.
INCHES		6.41	13.01	14.95	14.95
MM		162.93	330.50	379.82	379.82
AC-FT		492.	999.	1148.	1148.
THOUS CU M		607.	1232.	1416.	1416.

PLATE D-15

STATION000002

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

	0.	400.	800.	1200.	1600.	2000.	2400.	2800.	3200.	0.	0.	0.	0.
.30	1												
1.00	2												
1.30	3												
2.00	4												
2.30	5												
3.00	6												
3.30	7												
4.00	8												
4.30	9												
5.00	10												
5.30	11												
6.00	12												
6.30	13												
7.00	14												
7.30	15												
8.00	16												
8.30	17												
9.00	18												
9.30	19												
10.00	20												
10.30	21												
11.00	22												
11.30	23												
12.00	24												
12.30	25												
13.00	26												
13.30	27												
14.00	28												
14.30	29												
15.00	30												
15.30	31												
16.00	32												
16.30	33												
17.00	34												
17.30	35												
18.00	36												
18.30	37												
19.00	38												
19.30	39												
20.00	40												
20.30	41												
21.00	42												
21.30	43												
22.00	44												
22.30	45												
23.00	46												
23.30	47												
0.00	48												
.30	49												
1.00	50												
1.30	51												
2.00	52												
2.30	53												
3.00	54												
3.30	55												
4.00	56												

PLATE D-16

PLATE D-17

PLATE D-18

STATION 000002, PLAN 1, RATIO 6 PMF

END OF PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	2.	2.	3.	4.	6.	8.	12.	16.
20.	27.	36.	50.	66.	77.	83.	87.	86.	84.
81.	78.	75.	71.	68.	65.	63.	60.	58.	58.
60.	63.	67.	70.	74.	77.	81.	84.	87.	90.
94.	102.	139.	175.	212.	248.	282.	311.	337.	361.
384.	405.	432.	484.	568.	675.	797.	932.	1113.	1401.
1835.	2272.	2534.	2642.	2651.	2567.	2407.	2212.	2014.	1827.
1665.	1499.	1360.	1235.	1124.	1025.	953.	890.	827.	767.
711.	660.	613.	570.	530.	493.	460.	429.	400.	374.
349.	327.	306.	287.	267.	249.	233.	218.	205.	192.
181.	170.	161.	152.	144.	137.	131.	125.	119.	114.
110.	106.	102.	99.	97.	95.	93.	92.	90.	89.
87.	86.	85.	83.						

STORAGE

749.	749.	749.	749.	749.	749.	749.	749.	749.	749.
749.	749.	749.	749.	749.	749.	749.	749.	749.	750.
750.	750.	751.	752.	752.	754.	756.	759.	763.	769.
774.	783.	797.	811.	823.	830.	835.	837.	837.	836.
833.	831.	829.	826.	824.	822.	820.	818.	817.	817.
818.	821.	823.	826.	828.	831.	833.	836.	838.	840.
843.	851.	865.	881.	898.	914.	930.	944.	957.	970.
981.	992.	1005.	1032.	1074.	1128.	1190.	1258.	1333.	1435.
1540.	1746.	1840.	1878.	1881.	1851.	1794.	1725.	1654.	1587.
1526.	1471.	1421.	1376.	1337.	1301.	1269.	1237.	1205.	1175.
1147.	1121.	1097.	1075.	1055.	1037.	1020.	1004.	989.	976.
963.	952.	942.	932.	923.	915.	908.	901.	895.	889.
884.	879.	875.	871.	868.	864.	861.	859.	856.	854.
852.	850.	848.	847.	845.	844.	843.	841.	840.	839.
838.	837.	836.	835.						

STAGE

980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0
980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0	980.0
980.0	980.0	980.0	980.0	980.0	980.1	980.1	980.1	980.2	980.2
980.3	980.4	980.5	980.7	980.8	980.9	981.0	981.0	981.0	981.0
980.9	980.9	980.9	980.9	980.8	980.8	980.8	980.8	980.8	980.8
980.8	980.8	980.8	980.9	980.9	980.9	980.9	981.0	981.0	981.0
981.1	981.1	981.3	981.5	981.6	981.8	982.0	982.1	982.2	982.3
982.4	982.5	982.7	982.9	983.2	983.6	984.0	984.5	985.0	985.7
986.7	987.8	988.4	988.6	988.7	988.5	988.1	987.6	987.1	986.7
986.3	985.9	985.6	985.3	985.0	984.8	984.5	984.3	984.1	983.9
983.7	983.5	983.4	983.2	983.1	983.0	982.8	982.7	982.5	982.4
982.3	982.2	982.1	982.0	981.9	981.8	981.7	981.7	981.6	981.5
981.5	981.4	981.4	981.3	981.3	981.3	981.2	981.2	981.2	981.2
981.1	981.1	981.1	981.1	981.1	981.1	981.0	981.0	981.0	981.0
981.0	981.0	981.0	981.0						

PEAK OUTFLOW IS 2651. AT TIME 42.50 HOURS.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2651.	2177.	1027.	372.	56440.

PLATE D-19

CMS	75.	62.	29.	11.	1598.
INCHES		14.03	26.53	30.38	30.38
MM		356.41	673.83	771.73	771.73
AC-FT		1077.	2036.	2332.	2332.
THOUS CU M		1329.	2512.	2877.	2877.

PLATE D-20

HOVER

STATION000002

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

	0.	1000.	2000.	3000.	4000.	5000.	6000.	7000.	0.	0.	0.	0.	0.
.30	11												
1.00	21												
1.30	31												
2.00	41												
2.30	51												
3.00	61												
3.30	71												
4.00	81												
4.30	91												
5.00	101												
5.30	111												
6.00	121												
6.30	131												
7.00	141												
7.30	151												
8.00	161												
8.30	171												
9.00	181												
9.30	191												
10.00	201												
10.30	211												
11.00	221												
11.30	231												
12.00	241												
12.30	251												
13.00	261												
13.30	271												
14.00	281												
14.30	291												
15.00	301												
15.30	311												
16.00	321												
16.30	331												
17.00	341												
17.30	351												
18.00	361												
18.30	371												
19.00	381												
19.30	391												
20.00	401												
20.30	411												
21.00	421												
21.30	431												
22.00	441												
22.30	451												
23.00	461												
23.30	471												
0.00	481												
.30	491												
1.00	501												
1.30	511												
2.00	521												
2.30	531												
3.00	541												
3.30	551												
4.00	561												

PLATE D-21

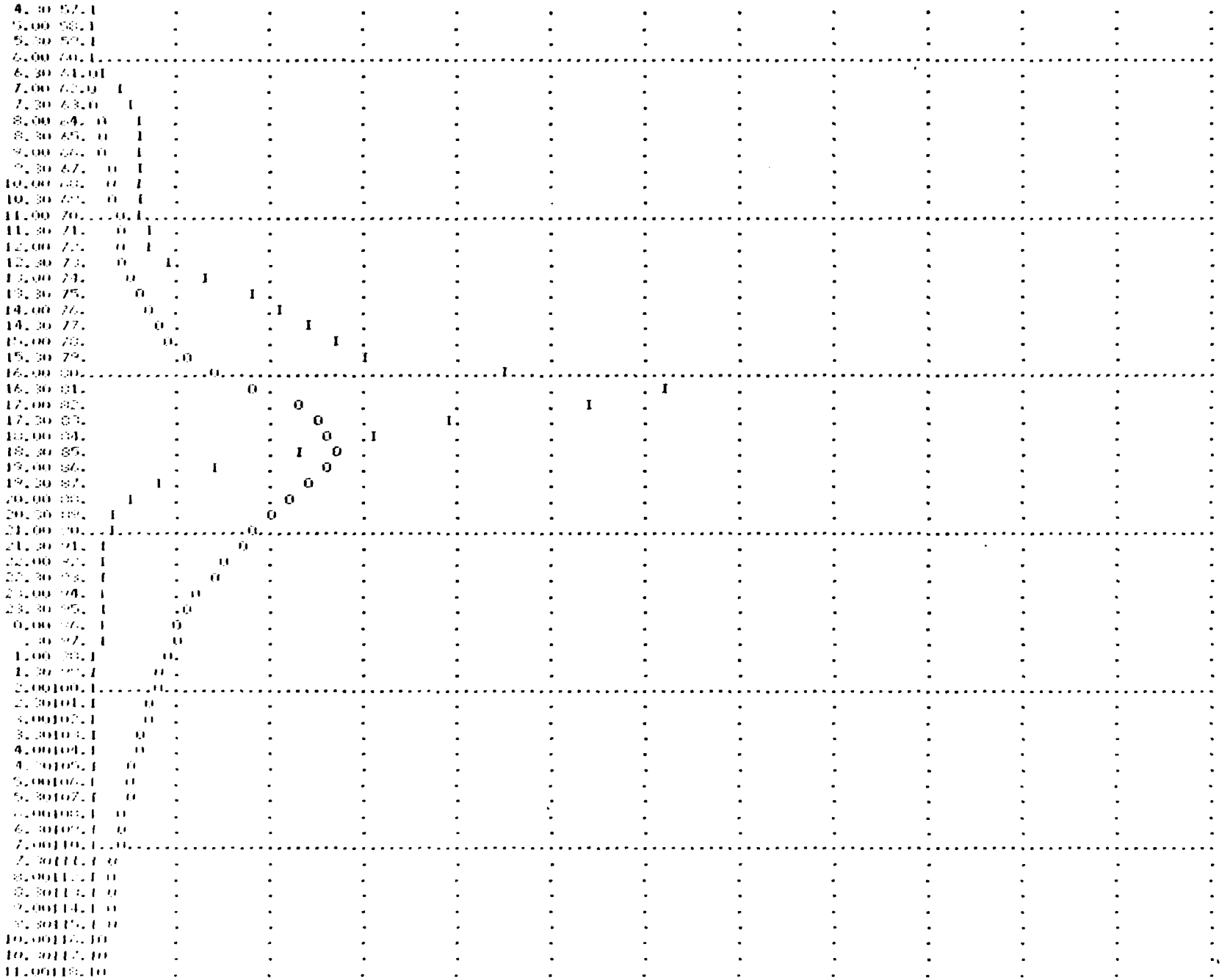


PLATE D-22

********** ********** ********** ********** **********

SUB AREA RUNOFF COMPUTATION

CALCULATION OF INFLOW HYDRO TO RES NO 10007

ISTAO	ICOMP	ICON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000003	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDR	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	22.91	0.00	22.91	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.70	93.00	111.00	121.00	131.00	0.00	0.00

LOSS DATA

LOSS	STRKR	DLTKR	RTIOK	ERAIN	STRFS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-91.00	0.00	0.00

CURVE NO = -91.00 WETNESS = 1.00 EFFECT CN = 91.00

UNIT HYDROGRAPH DATA

TP= 0.00 LAG= 3.10

RECESSION DATA

STRTQ= 0.00 QRCSN= -.01 RTIOR= 1.00

UNIT HYDROGRAPH 33 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 3.10 VOL= 1.00

623.	1275.	2160.	2975.	3259.	3286.	3082.	2724.	2269.	
1710.	1308.	1023.	816.	645.	497.	395.	310.	241.	187.
145.	117.	91.	72.	56.	44.	35.	29.	23.	17.
13.	7.	2.							

END-OF PERIOD FLOW

IDAY	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.30	1	.01	0.00	.01	0.	1.02	12.30	73	1.10	1.09	.01	7383.
1.01	1.00	2	.01	0.00	.01	0.	1.02	13.00	74	1.10	1.09	.01	10054.
1.01	1.30	3	.01	0.00	.01	0.	1.02	13.30	75	1.32	1.31	.01	11241.
1.01	2.00	4	.01	0.00	.01	0.	1.02	14.00	76	1.32	1.31	.01	11431.
1.01	2.30	5	.01	0.00	.01	0.	1.02	14.30	77	1.65	1.64	.01	13736.
1.01	3.00	6	.01	0.00	.01	0.	1.02	15.00	78	1.65	1.65	.01	18034.
1.01	3.30	7	.01	0.00	.01	0.	1.02	15.30	79	2.01	2.00	.01	22463.
1.01	4.00	8	.01	0.00	.01	0.	1.02	16.00	80	4.37	4.35	.01	27417.
1.01	4.30	9	.01	0.00	.01	0.	1.02	16.30	81	1.54	1.54	.00	33405.
1.01	5.00	10	.01	0.00	.01	0.	1.02	17.00	82	1.54	1.54	.00	40220.
1.01	5.30	11	.01	0.00	.01	0.	1.02	17.30	83	1.21	1.21	.00	47455.
1.01	6.00	12	.01	0.00	.01	0.	1.02	18.00	84	1.21	1.21	.00	53030.
1.01	6.30	13	.03	0.00	.03	0.	1.02	18.30	85	.12	.12	.00	56545.
1.01	7.00	14	.03	0.00	.03	0.	1.02	19.00	86	.12	.12	.00	56955.
1.01	7.30	15	.03	0.00	.03	0.	1.02	19.30	87	.12	.12	.00	56437.
1.01	8.00	16	.03	0.00	.03	0.	1.02	20.00	88	.12	.12	.00	48855.
1.01	8.30	17	.03	.00	.03	0.	1.02	20.30	89	.12	.12	.00	42755.
1.01	9.00	18	.03	.00	.03	1.	1.02	21.00	90	.12	.12	.00	35787.
1.01	9.30	19	.03	.00	.03	3.	1.02	21.30	91	.12	.12	.00	29705.
1.01	10.00	20	.03	.01	.02	8.	1.02	22.00	92	.12	.12	.00	24314.

1.01	10.30	41	.03	.01	.02	17.	1.02	22.30	94	.12	.12	.00	[illegible]
1.01	11.00	42	.03	.01	.02	30.	1.02	23.00	94	.12	.12	.00	16306.
1.01	11.30	43	.03	.01	.02	47.	1.02	23.30	95	.12	.12	.00	14430.
1.01	12.00	44	.03	.01	.02	68.	1.03	0.00	96	.12	.12	.00	11768.
1.01	12.30	45	.09	.04	.06	98.	1.03	.30	97	0.00	0.00	0.00	9855.
1.01	13.00	46	.09	.04	.05	142.	1.03	1.00	98	0.00	0.00	0.00	8232.
1.01	13.30	47	.11	.06	.05	209.	1.03	1.30	99	0.00	0.00	0.00	7022.
1.01	14.00	48	.11	.07	.04	311.	1.03	2.00	100	0.00	0.00	0.00	5963.
1.01	14.30	49	.14	.09	.05	453.	1.03	2.30	101	0.00	0.00	0.00	4984.
1.01	15.00	50	.14	.10	.04	637.	1.03	3.00	102	0.00	0.00	0.00	4095.
1.01	15.30	51	.17	.13	.04	864.	1.03	3.30	103	0.00	0.00	0.00	3383.
1.01	16.00	52	.53	.43	.10	1195.	1.03	4.00	104	0.00	0.00	0.00	2656.
1.01	16.30	53	.13	.11	.02	1615.	1.03	4.30	105	0.00	0.00	0.00	2067.
1.01	17.00	54	.13	.11	.02	2122.	1.03	5.00	106	0.00	0.00	0.00	1605.
1.01	17.30	55	.10	.09	.01	2682.	1.03	5.30	107	0.00	0.00	0.00	1256.
1.01	18.00	56	.10	.09	.01	3150.	1.03	6.00	108	0.00	0.00	0.00	977.
1.01	18.30	57	.01	.01	.00	3444.	1.03	6.30	109	0.00	0.00	0.00	752.
1.01	19.00	58	.01	.01	.00	3583.	1.03	7.00	110	0.00	0.00	0.00	570.
1.01	19.30	59	.01	.01	.00	3444.	1.03	7.30	111	0.00	0.00	0.00	557.
1.01	20.00	60	.01	.01	.00	3194.	1.03	8.00	112	0.00	0.00	0.00	557.
1.01	20.30	61	.01	.01	.00	2878.	1.03	8.30	113	0.00	0.00	0.00	557.
1.01	21.00	62	.01	.01	.00	2586.	1.03	9.00	114	0.00	0.00	0.00	557.
1.01	21.30	63	.01	.01	.00	1986.	1.03	9.30	115	0.00	0.00	0.00	557.
1.01	22.00	64	.01	.01	.00	1639.	1.03	10.00	116	0.00	0.00	0.00	557.
1.01	22.30	65	.01	.01	.00	1349.	1.03	10.30	117	0.00	0.00	0.00	557.
1.01	23.00	66	.01	.01	.00	1108.	1.03	11.00	118	0.00	0.00	0.00	557.
1.01	23.30	67	.01	.01	.00	921.	1.03	11.30	119	0.00	0.00	0.00	557.
1.02	0.00	68	.01	.01	.00	781.	1.03	12.00	120	0.00	0.00	0.00	557.
1.02	.30	69	.08	.07	.01	683.	1.03	12.30	121	0.00	0.00	0.00	557.
1.02	1.00	70	.08	.07	.01	683.	1.03	13.00	122	0.00	0.00	0.00	557.
1.02	1.30	71	.08	.07	.01	683.	1.03	13.30	123	0.00	0.00	0.00	557.
1.02	2.00	72	.08	.07	.01	726.	1.03	14.00	124	0.00	0.00	0.00	557.
1.02	2.30	73	.08	.07	.01	865.	1.03	14.30	125	0.00	0.00	0.00	557.
1.02	3.00	74	.08	.07	.01	1038.	1.03	15.00	126	0.00	0.00	0.00	557.
1.02	3.30	75	.08	.07	.01	1222.	1.03	15.30	127	0.00	0.00	0.00	557.
1.02	4.00	76	.08	.07	.01	1399.	1.03	16.00	128	0.00	0.00	0.00	557.
1.02	4.30	77	.08	.07	.01	1553.	1.03	16.30	129	0.00	0.00	0.00	557.
1.02	5.00	78	.08	.07	.01	1654.	1.03	17.00	130	0.00	0.00	0.00	557.
1.02	5.30	79	.08	.07	.00	1707.	1.03	17.30	131	0.00	0.00	0.00	557.
1.02	6.00	80	.08	.07	.00	1670.	1.03	18.00	132	0.00	0.00	0.00	557.
1.02	6.30	81	.36	.34	.02	1727.	1.03	18.30	133	0.00	0.00	0.00	557.
1.02	7.00	82	.36	.34	.02	2218.	1.03	19.00	134	0.00	0.00	0.00	557.
1.02	7.30	83	.36	.34	.01	3541.	1.03	19.30	135	0.00	0.00	0.00	557.
1.02	8.00	84	.36	.34	.01	3195.	1.03	20.00	136	0.00	0.00	0.00	557.
1.02	8.30	85	.36	.34	.01	2835.	1.03	20.30	137	0.00	0.00	0.00	557.
1.02	9.00	86	.36	.35	.01	4878.	1.03	21.00	138	0.00	0.00	0.00	557.
1.02	9.30	87	.36	.35	.01	5279.	1.03	21.30	139	0.00	0.00	0.00	557.
1.02	10.00	88	.36	.35	.01	4478.	1.03	22.00	140	0.00	0.00	0.00	557.
1.02	10.30	89	.36	.35	.01	7884.	1.03	22.30	141	0.00	0.00	0.00	557.
1.02	11.00	90	.36	.35	.01	8041.	1.03	23.00	142	0.00	0.00	0.00	557.
1.02	11.30	91	.36	.35	.01	8507.	1.03	23.30	143	0.00	0.00	0.00	557.
1.02	12.00	92	.36	.35	.01	8850.	1.04	0.00	144	0.00	0.00	0.00	557.
									SUM	41.05	29.87	1.14	[illegible]
										(73%.)	(75%.)	(2%.)	(25510.4.)

	TOTAL	6 HOUR	24 HOUR	72 HOUR	TOTAL VOLUME
CFS	[illegible]	4[illegible].	1[illegible].	[illegible].	[illegible]
CMS	1[illegible]	1[illegible].	4[illegible].	12.	[illegible]
INCHES		1.77	[illegible]	10.47	10.47
MM		44[illegible]	2[illegible]	274.04	274.04
AC FT		1[illegible]	34200.	[illegible]	[illegible]

PLATE D-25

THOUS CU M		2[illegible]71.	42106.	45705.	45705.

HYDROGRAPH AT STA00000003 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11189.	8705.	3449.	1251.	180125.
CMS	317.	246.	98.	35.	5101.
INCHES		3.53	5.60	6.09	6.09
MM		89.78	142.26	154.81	154.81
AC-FT		4316.	6840.	7443.	7443.
THOUS CU M		5324.	8437.	9181.	9181.

HYDROGRAPH AT STA00000003 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	19581.	15233.	6035.	2189.	315219.
CMS	554.	431.	171.	62.	8926.
INCHES		6.19	9.80	10.67	10.67
MM		157.11	248.96	270.91	270.91
AC-FT		7554.	11970.	13026.	13026.
THOUS CU M		9317.	14765.	16067.	16067.

HYDROGRAPH AT STA00000003 FOR PLAN 1, RTIO 3 ½ PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	27972.	21762.	8621.	3127.	450313.
CMS	792.	616.	244.	89.	12751.
INCHES		8.84	14.00	15.24	15.24
MM		224.44	355.66	387.02	387.02
AC-FT		10791.	17100.	18608.	18608.
THOUS CU M		13310.	21093.	22953.	22953.

HYDROGRAPH AT STA00000003 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	36364.	28290.	11208.	4065.	585407.
CMS	1030.	801.	317.	115.	16577.
INCHES		11.49	18.20	19.81	19.81
MM		291.77	462.36	503.13	503.13
AC-FT		14033.	22230.	24190.	24190.
THOUS CU M		17304.	27421.	29838.	29838.

HYDROGRAPH AT STA00000003 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	44744.	34814.	13794.	5003.	720601.
CMS	1267.	986.	391.	142.	20406.
INCHES		14.14	22.40	24.38	24.38
MM		359.10	568.95	619.23	619.23
AC-FT		17269.	27360.	29777.	29777.
THOUS CU M		21294.	33748.	36734.	36734.

HYDROGRAPH AT STA00000S FOR PLAN 1, RTIO 4 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	59745.	43524.	17243.	6254.	900627.
CMS	1584.	1232.	488.	177.	25503.
INCHES		17.67	28.00	30.47	30.47
MM		448.83	711.32	774.04	774.04
AC-FT		21587.	34200.	37216.	37216.
THOUS CU M		26621.	42186.	45905.	45905.

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINED INFLOW HYDROGRAPH TO RESERVOIR 10007

	ISTAO	ICOMP	ICLON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
UM 2+3		2	0	0	2	0	1	0	0

SUM OF 2 HYDROGRAPHS AT UM 2+3 PLAN 1 RTIO 1

	PEAK	6-HOUR	24 HOUR	72 HOUR	TOTAL VOLUME
CFS	11693.	9088.	3626.	1326.	190935.
CMS	330.	257.	103.	38.	5407.
INCHES		3.47	5.54	6.08	6.08
MM		88.18	140.74	154.39	154.39
AC-FT		4506.	7192.	7890.	7890.
THOUS CU M		5558.	8871.	9732.	9732.

PLATE D-27

DVN

SUM OF 2 HYDROGRAPHS AT UM 2+3 PLAN 1 RTIO 3 [1/2 PMF]

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	29169.	22253.	9099.	3320.	478091.
CMS	826.	644.	258.	94.	13538.
INCHES		8.69	13.90	15.22	15.22
MM		220.78	353.16	386.59	386.59
AC-FT		11282.	18047.	19756.	19756.
THOUS CU M		13917.	22261.	24368.	24368.

PLATE D-28

OVF

STATION NUM 2+3

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

	0.	1000.	8000.	12000.	16000.	20000.	24000.	28000.	32000.	0.	0.	0.	0.
.30	11												
1.00	21												
1.30	31												
2.00	41												
2.30	51												
3.00	61												
3.30	71												
4.00	81												
4.30	91												
5.00	101												
5.30	111												
6.00	121												
6.30	131												
7.00	141												
7.30	151												
8.00	161												
8.30	171												
9.00	181												
9.30	191												
10.00	201												
10.30	211												
11.00	221												
11.30	231												
12.00	241												
12.30	251												
13.00	261												
13.30	271												
14.00	281												
14.30	291												
15.00	301												
15.30	31.												
16.00	32.	I											
16.30	33.	I											
17.00	34.	I											
17.30	35.	I											
18.00	36.	I											
18.30	37.	I											
19.00	38.	I											
19.30	39.	I											
20.00	40.	I											
20.30	41.	I											
21.00	42.	I											
21.30	43.	I											
22.00	44.	I											
22.30	45.	I											
23.00	46.	I											
23.30	47.	I											
0.00	48.	I											
.30	49.	I											
1.00	50.	I											
1.30	51.	I											
2.00	52.	I											
2.30	53.	I											
3.00	54.	I											
3.30	55.	I											
4.00	56.	I											

PLATE D-29

PLATE D-30

PLATE D-31

«IVN»

SUM OF 2 HYDROGRAPHS AT UM 2+3 PLAN 1 RTIO 6 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	58596.	45696.	18230.	6446.	957067.
CMS	1659.	1294.	516.	188.	27101.
INCHES		17.46	27.86	30.47	30.47
MM		443.41	707.57	773.90	773.90
AC-FT		22659.	36158.	39548.	39548.
THOUS CU M		27950.	44601.	48782.	48782.

MOVE 4

STATIONUM 243

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

	0.	10000.	20000.	30000.	40000.	50000.	60000.	0.	0.	0.	0.	0.	0.
.30	11												
1.00	21												
1.30	31												
2.00	41												
2.30	51												
3.00	61												
3.30	71												
4.00	81												
4.30	91												
5.00	101												
5.30	111												
6.00	121												
6.30	131												
7.00	141												
7.30	151												
8.00	161												
8.30	171												
9.00	181												
9.30	191												
10.00	201												
10.30	211												
11.00	221												
11.30	231												
12.00	241												
12.30	251												
13.00	261												
13.30	271												
14.00	281												
14.30	291												
15.00	301												
15.30	311												
16.00	321												
16.30	331												
17.00	341												
17.30	351												
18.00	361												
18.30	371												
19.00	381												
19.30	391												
20.00	401												
20.30	411												
21.00	421												
21.30	431												
22.00	441												
22.30	451												
23.00	461												
23.30	471												
0.00	481												
.30	491												
1.00	501												
1.30	511												
2.00	521												
2.30	531												
3.00	541												
3.30	551												
4.00	561												

PLATE D-33

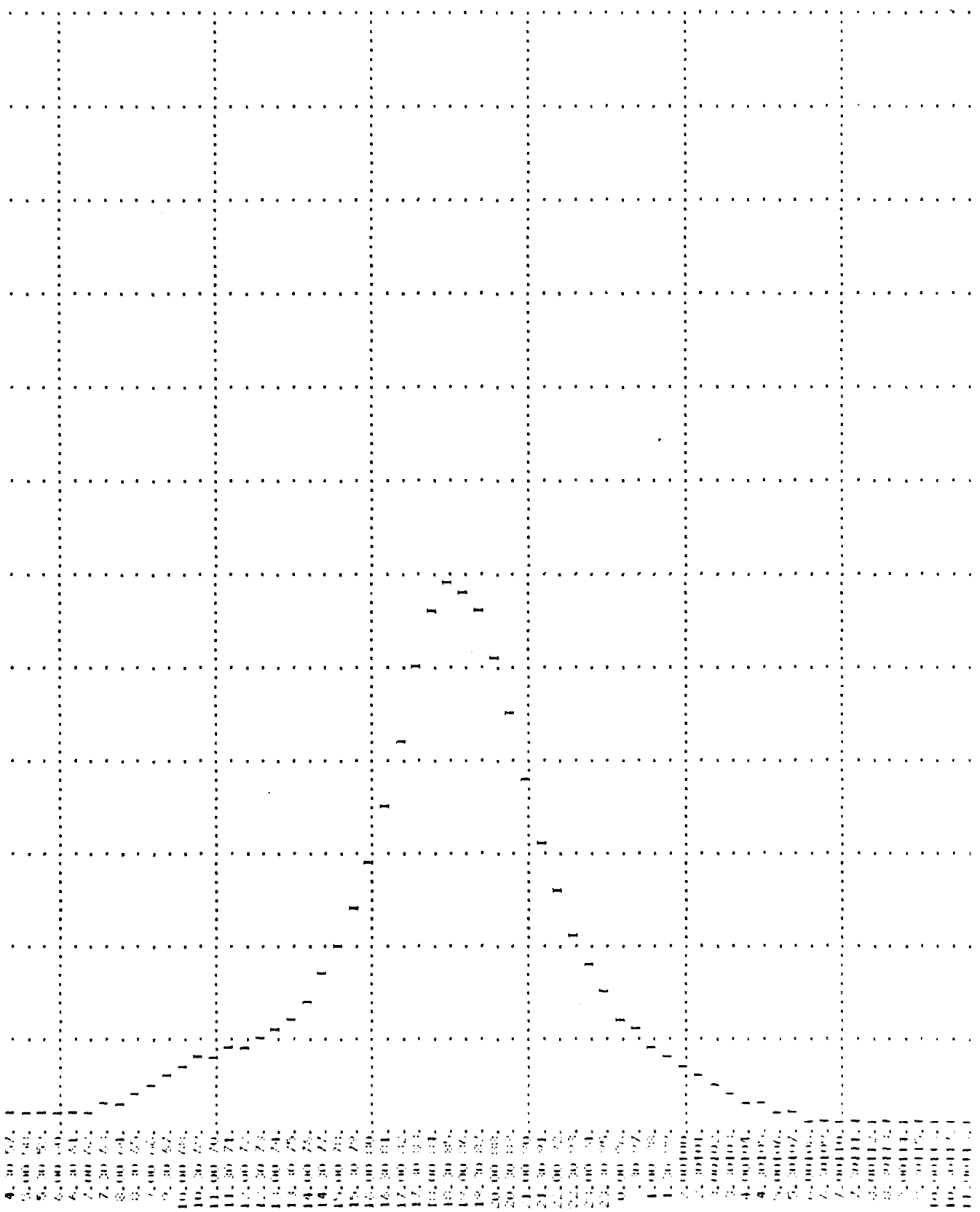


PLATE D-34

PLATE D-35

IVN

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTED FLOWS THRU RESERVOIR NO 10007

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
000004	1	0	0	2	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-969.	-1

STAGE	969.00	969.50	970.00	971.00	972.00	972.30	973.00	973.40	974.00	975.00
	976.00	977.40	978.00	980.00						
FLOW	0.00	62.00	176.00	497.00	915.00	1050.00	1170.00	1310.00	1550.00	2340.00
	4470.00	8270.00	10400.00	19400.00						
STORAGE (AC-FT)	0.	60.	190.	360.	620.	858.	990.	1110.	1240.	1370.
	1490.	1610.	1745.							
CAPACITY	0.	130.	1319.	4024.	8866.	13281.	15127.	17226.	19575.	22184.
	25043.	28142.	31496.							
ELEVATION	924.	930.	940.	950.	960.	966.	968.	970.	972.	974.
	976.	978.	980.							

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
969.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
977.4	3.0	1.5	1550.

CREST LENGTH	0.	50.	200.	350.	400.	650.	1150.	1520.
AT OR BELOW ELEVATION	977.4	977.6	978.0	978.3	979.0	979.2	979.6	980.0

~~STATION 000004, PLAN 1, RATIO 1~~

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	1.	1.	1.	2.
3.	3.	5.	7.	9.	12.	15.	18.	22.	25.
28.	30.	32.	34.	35.	36.	37.	38.	48.	49.
39.	40.	41.	41.	42.	43.	45.	46.	48.	49.
51.	53.	55.	57.	61.	67.	77.	84.	98.	111.
124.	138.	153.	172.	190.	217.	250.	289.	336.	392.
450.	506.	678.	817.	966.	1078.	1173.	1303.	1394.	1377.
1441.	1474.	1535.	1574.	1615.	1641.	1657.	1664.	1666.	1661.
1654.	1635.	1620.	1593.	1575.	1549.	1535.	1521.	1506.	1490.
1474.	1459.	1443.	1428.	1413.	1398.	1383.	1368.	1353.	1337.

PLATE D-36

RIVN+

STATION 000004, PLAN 1, RATIO = [1/2 PMF]

END OF PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	1.	1.	1.	2.	3.	4.
6.	9.	12.	17.	22.	30.	37.	46.	54.	62.
74.	85.	94.	102.	107.	112.	116.	119.	121.	123.
125.	127.	130.	133.	137.	142.	147.	153.	159.	166.
173.	183.	196.	211.	231.	256.	284.	318.	356.	398.
443.	489.	548.	613.	684.	765.	861.	979.	1078.	1145.
1181.	1198.	1948.	3763.	4255.	5993.	7576.	9079.	10461.	11682.
12725.	12617.	12513.	12164.	11755.	11059.	10442.	9922.	9401.	8886.
8375.	7956.	7557.	7157.	6759.	6368.	5985.	5616.	5261.	4921.
4599.	4438.	4110.	3829.	3698.	3508.	3327.	3156.	2994.	2841.
2695.	2568.	2429.	2327.	2283.	2239.	2197.	2155.	2114.	2074.
2034.	1995.	1957.	1920.	1884.	1848.	1813.	1779.	1745.	1712.
1680.	1648.	1618.	1587.						

STORAGE

16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.
16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.	16147.
16147.	16147.	16148.	16149.	16151.	16154.	16157.	16163.	16171.	16182.
16193.	16209.	16228.	16287.	16337.	16398.	16466.	16538.	16609.	16677.
16737.	16789.	16832.	16867.	16895.	16917.	16934.	16948.	16960.	16970.
16979.	16987.	17001.	17017.	17036.	17059.	17085.	17114.	17145.	17178.
17213.	17250.	17294.	17348.	17416.	17500.	17603.	17724.	17860.	18009.
18169.	18337.	18512.	18697.	18901.	19135.	19415.	19753.	20160.	20656.
21259.	22004.	22881.	23869.	24899.	25891.	26788.	27544.	28127.	28518.
28732.	28800.	28774.	28668.	28510.	28323.	28119.	27905.	27684.	27459.
27233.	27006.	26777.	26548.	26323.	26102.	25887.	25681.	25484.	25296.
25119.	24954.	24798.	24651.	24511.	24380.	24255.	24138.	24027.	23922.
23824.	23731.	23643.	23560.	23480.	23402.	23325.	23250.	23176.	23104.
23034.	22965.	22898.	22832.	22768.	22704.	22643.	22583.	22524.	22466.
22410.	22355.	22301.	22248.						

STAGE

969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0
969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0
969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0
969.0	969.1	969.1	969.1	969.2	969.2	969.3	969.4	969.4	969.5
969.6	969.6	969.6	969.7	969.7	969.7	969.7	969.7	969.8	969.8
969.8	969.8	969.8	969.8	969.8	969.8	969.9	969.9	969.9	970.0
970.0	970.0	970.1	970.1	970.2	970.2	970.3	970.4	970.6	970.7
970.8	971.0	971.1	971.3	971.4	971.6	971.9	972.1	972.5	972.9
973.3	973.9	974.5	975.2	975.9	976.6	977.1	977.5	978.0	978.2
978.4	978.4	978.4	978.3	978.2	978.1	978.0	977.9	977.7	977.6
977.5	977.3	977.1	977.0	976.8	976.7	976.6	976.4	976.3	976.2
976.1	976.0	975.8	975.7	975.6	975.6	975.5	975.4	975.3	975.2
975.2	975.1	975.0	975.0	974.9	974.9	974.8	974.8	974.7	974.7
974.6	974.6	974.5	974.5	974.4	974.4	974.3	974.3	974.2	974.2
974.1	974.1	974.1	974.0						

PEAK OUTFLOW IS [illegible] AT TIME 46.00 HOURS.

	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PLATE D-37

CMS	50%	314.	171.	45.	9558.
INCHES		4.24	6.24	10.59	10.59
MM		107.77	234.76	442.21	267.21
AC-FT		9507.	11997.	13654.	13656.
HDBT-CU M		6703.	14790.	16845.	16845.

PLATE D-38

STATION000004

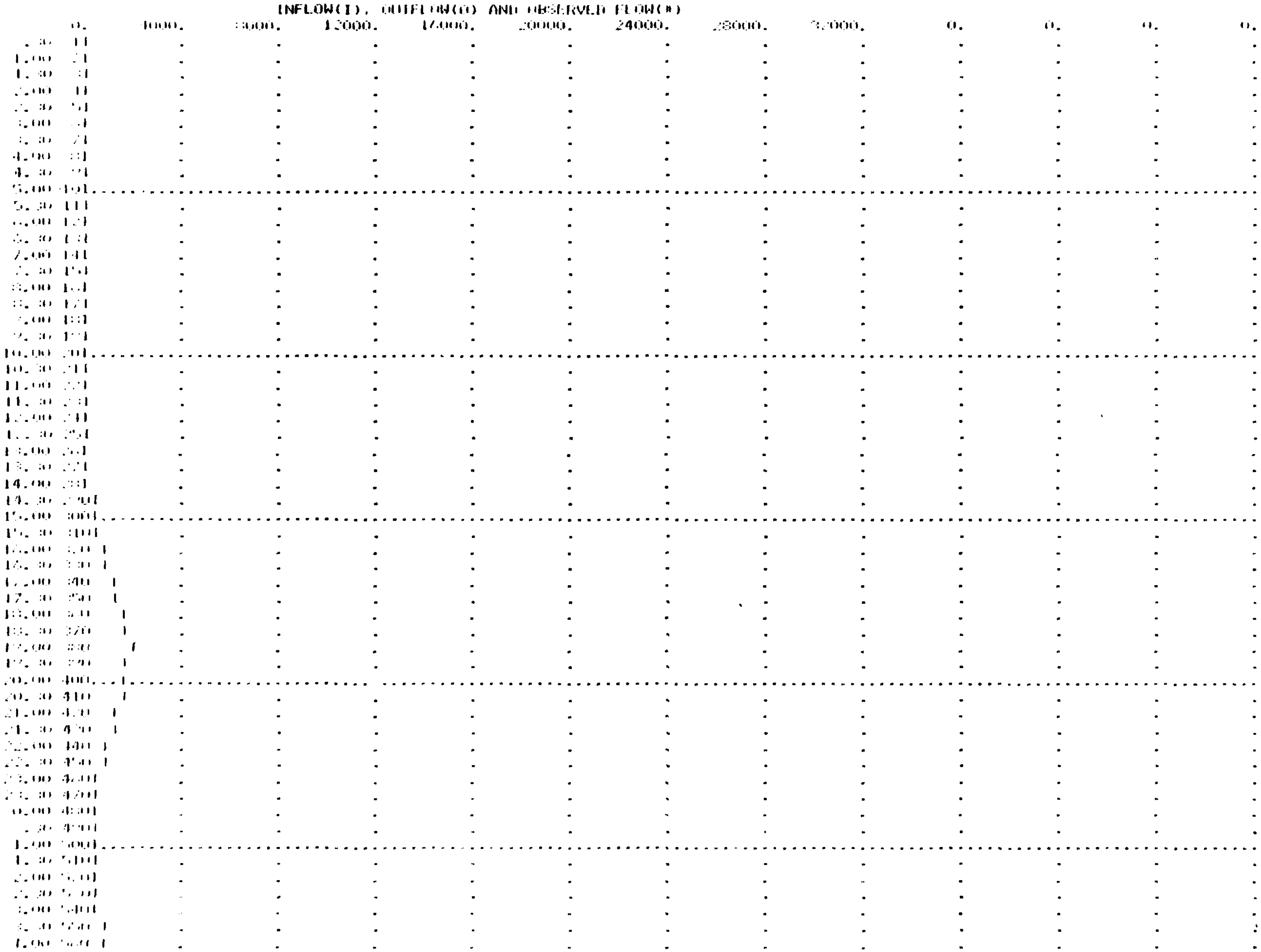


PLATE D-39

PLATE D-40

PLATE D-41

IOVN

STATION 000004, PLAN 1, RATIO 6 PMF

END OF PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	1.	1.	2.	3.	4.	6.	8.
12.	17.	24.	33.	45.	59.	85.	115.	144.	172.
205.	234.	258.	277.	292.	304.	313.	319.	325.	329.
334.	338.	344.	352.	362.	374.	387.	402.	419.	436.
454.	474.	497.	534.	581.	640.	710.	792.	883.	987.
1079.	1113.	1160.	1247.	1361.	1501.	1774.	2152.	3011.	4361.
6195.	8692.	12734.	18363.	26178.	34432.	40748.	44414.	45438.	44195.
41372.	37745.	33865.	30081.	26608.	23591.	21094.	19051.	17348.	15886.
14659.	13634.	12173.	11103.	10191.	9457.	8774.	8162.	7685.	7221.
6830.	6465.	5975.	5410.	5267.	4947.	4647.	4387.	4179.	3983.
3796.	3619.	3451.	3291.	3140.	2997.	2862.	2734.	2613.	2498.
2390.	2320.	2283.	2246.	2210.	2175.	2140.	2106.	2073.	2040.
2008.	1977.	1946.	1916.						

STORAGE

16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.
16146.	16146.	16146.	16146.	16146.	16146.	16146.	16146.	16147.	16147.
16147.	16148.	16150.	16152.	16156.	16161.	16168.	16179.	16195.	16218.
16249.	16292.	16351.	16428.	16528.	16650.	16786.	16930.	17072.	17206.
17326.	17428.	17511.	17578.	17631.	17672.	17704.	17728.	17748.	17764.
17779.	17796.	17817.	17845.	17880.	17922.	17970.	18025.	18083.	18145.
18211.	18283.	18367.	18471.	18605.	18772.	18975.	19213.	19481.	19775.
20089.	20430.	20767.	21137.	21545.	22015.	22574.	23245.	24038.	24973.
26078.	27374.	28841.	30381.	31821.	32988.	33798.	34246.	34369.	34220.
33875.	33419.	32913.	32394.	31887.	31407.	30959.	30537.	30136.	29750.
29381.	29018.	28670.	28337.	28017.	27708.	27410.	27124.	26850.	26585.
26334.	26100.	25881.	25677.	25487.	25310.	25145.	24991.	24846.	24709.
24577.	24456.	24340.	24231.	24127.	24029.	23937.	23850.	23767.	23690.
23617.	23547.	23479.	23413.	23348.	23285.	23223	23162.	23103.	23045.
22988.	22932.	22878.	22825.						

STAGE

969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0
969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0
969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.0	969.1
969.1	969.1	969.2	969.3	969.4	969.5	969.6	969.7	969.9	970.0
970.1	970.2	970.3	970.3	970.4	970.4	970.4	970.4	970.5	970.5
970.5	970.5	970.5	970.5	970.6	970.6	970.7	970.7	970.8	970.8
970.9	970.9	971.0	971.1	971.2	971.3	971.5	971.7	971.9	972.2
972.4	972.7	972.9	973.2	973.5	973.9	974.3	974.8	975.3	976.0
976.7	977.5	978.4	979.4	980.3	980.8	981.3	981.5	981.6	981.5
981.3	981.1	980.8	980.5	980.2	979.9	979.7	979.4	979.2	979.0
978.8	978.5	978.3	978.1	977.9	977.7	977.5	977.4	977.2	977.0
976.9	976.7	976.6	976.4	976.3	976.2	976.1	976.0	975.9	975.8
975.7	975.6	975.5	975.4	975.4	975.3	975.2	975.2	975.1	975.1
975.0	975.0	974.9	974.9	974.8	974.8	974.7	974.7	974.7	974.6
974.6	974.5	974.5	974.5						

PEAK OUTFLOW IS 45438. AT TIME 44.50 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	45438.	37510.	17530.	5654.	2598...

PLATE D-42

CMS	1287.	1006.	431.	156.	22525.
INCHES		13.57	23.26	25.32	25.32
MM		344.57	590.73	643.22	643.22
AC-FT		17608.	30188.	32870.	32870.
THOUS CU M		21720.	37236.	40544.	40544.

PLATE D-43

UVH

STATION000004

INFLOW(I), OUTFLOW(O) AND OBSERVED FLOW(*)

	0.	10000.	20000.	30000.	40000.	50000.	60000.	0.	0.	0.	0.	0.	0.
.30	11												
1.00	21												
1.30	31												
2.00	41												
2.30	51												
3.00	61												
3.30	71												
4.00	81												
4.30	91												
5.00	101												
5.30	111												
6.00	121												
6.30	131												
7.00	141												
7.30	151												
8.00	161												
8.30	171												
9.00	181												
9.30	191												
10.00	201												
10.30	211												
11.00	221												
11.30	231												
12.00	241												
12.30	251												
13.00	261												
13.30	271												
14.00	281												
14.30	291												
15.00	301												
15.30	311												
16.00	321												
16.30	331												
17.00	341												
17.30	351												
18.00	361												
18.30	371												
19.00	381												
19.30	391												
20.00	401												
20.30	411												
21.00	421												
21.30	431												
22.00	441												
22.30	451												
23.00	461												
23.30	471												
0.00	481												
.30	491												
1.00	501												
1.30	511												
2.00	521												
2.30	531												
3.00	541												
3.30	551												
4.00	561												

PLATE D-44

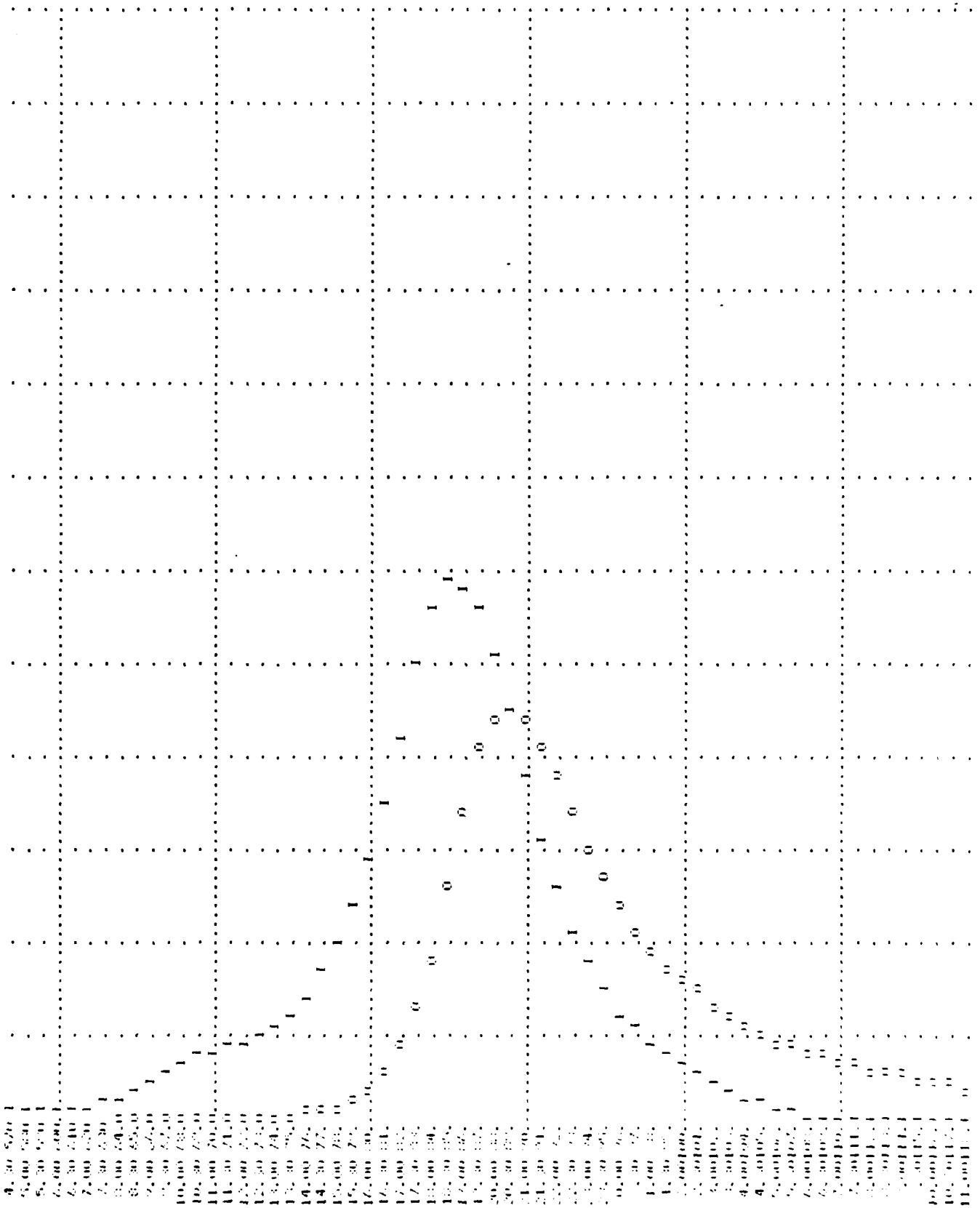


PLATE D-45

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS					
				RATIO 1 .20	RATIO 2 .35	RATIO 3 .50	RATIO 4 .65	RATIO 5 .80	RATIO 6 1.00
HYDROGRAPH AT	000001	1.44	1	1246.	2181.	3115.	4050.	4984.	6230.
		(3.73)	(	35.28)(	61.75)(	88.21)(	114.67)(	141.13)(	176.42)(
ROUTED TO	000002	1.44	1	449.	800.	1197.	1641.	2078.	2651.
		(3.73)	(	12.71)(	22.65)(	33.88)(	46.48)(	58.83)(	75.07)(
HYDROGRAPH AT	000003	22.91	1	11189.	19581.	27972.	36364.	44756.	55945.
		(59.34)	(	316.84)(	554.46)(	792.09)(	1029.72)(	1267.34)(	1584.18)(
2 COMBINED	HM 2+3	24.35	1	11638.	20381.	29169.	38006.	46833.	58596.
		(63.07)	(	329.55)(	577.12)(	825.97)(	1076.20)(	1326.18)(	1659.25)(
ROUTED TO	000004	24.35	1	1666.	6141.	12617.	21296.	31799.	45438.
		(63.07)	(	47.16)(	173.91)(	357.27)(	603.05)(	900.44)(	1286.66)(

PLATE D-47

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	930.00	980.00	993.00
STORAGE	749.	749.	2736.
OUTFLOW	0.	0.	4833.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	982.76	0.00	1014.	449.	0.00	42.50	0.00
.35	984.02	0.00	1192.	800.	0.00	42.50	0.00
.50	985.17	0.00	1363.	1197.	0.00	42.50	0.00
.65	986.24	0.00	1521.	1641.	0.00	42.50	0.00
.80	987.29	0.00	1677.	2078.	0.00	42.50	0.00
1.00	988.66	0.00	1881.	2651.	0.00	42.50	0.00

PLATE D-48

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	969.00	969.00	977.40
STORAGE	16146.	16146.	27187.
OUTFLOW	0.	0.	8270.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	974.15	0.00	22385.	1666.	0.00	49.50	0.00
.35	976.62	0.00	25975.	6141.	0.00	47.00	0.00
.50	978.41	1.01	28806.	12617.	7.00	46.00	0.00
.75	979.71	2.31	30998.	21296.	10.00	45.50	0.00
.80	980.64	3.24	32633.	31799.	11.50	45.00	0.00
1.00	981.60	4.20	34369.	45438.	13.00	44.50	0.00

PLATE D-49

APPENDIX E

FOUNDATION, EMBANKMENT AND INSPECTION REPORTS

APPENDIX E

DIVISION I

SOILS REPORT, PUTNAM COUNTY LAKE

OCTOBER, 1964

SOILS REPORT
PUTNAM COUNTY FARM
UNIONVILLE, CONNECTICUT

OCTOBER, 1964.

Dr. Thomas S. [illegible], P. E.

SOILS REPORT

[illegible]

[illegible]

INTRODUCTION

Results of the soils investigation that has been conducted at the site of the proposed dam in Putnam County Missouri are summarized in this report. Laboratory testing and analysis has been authorized by Mr. Earle Chamness of Wm. H. Klingner and Associates, Consulting Engineers, acting in behalf of the Putnam County Lake Association, sponsors of the project. Boring and sampling operations were conducted by the Missouri Conservation Commission under the direction of the Consulting Engineers.

SITE DESCRIPTION

Site of the proposed earth dam is located in the valley of Blackbird Creek about 1000 feet west of State Route 5 north of Unionville, Missouri. The stationing used to designate the centerline of the proposed dam originates on the north abutment and terminates at Station 16 + 90 on the south abutment. Borings located on the basis of a preliminary centerline survey originated at Station 0 on the north abutment and terminated at Station 16 + 25 on the south abutment. Exact location of these two lines and of all the borings is indicated on the Soil Boring Location Plan prepared by Klingner and Associates, dated October, 1964. The valley floor at the dam site is quite level and exists

[illegible] the valley floor is about 850 feet [illegible] of the proposed dam. At the north abutment the ground slope rises from the valley floor to elevation 977 between Station 7 + 60 and 0. The ground surface is somewhat steeper at the south abutment where the elevation changes from 935 to 977 between Stations 14 +20 and 16 + 90. At the north abutment the maximum elevation is about 977.

Elevations in excess of 1020 are reported for the ground surface above the terminus of the dam at the south abutment.

Currently the main channel of Blackbird Creek is about 25 feet wide and has a maximum depth of about 7 feet. With a crest elevation of about 977 and a water elevation of 970 the impounded lake will have a surface area of about 1200 acres.

Both of the abutments at this site consist of material derived from the activities of glaciers. By means of borings and laboratory tests on representative samples the characteristics of this glacial drift have been established. The relatively flat valley bottom results from the deposition of alluvium in a valley that was carved into the glacial till. Borings were made to determine the depth and character of the [illegible] in the valley.

characteristics of the subsoil along the centerline of the dam, the valley sediments above and below the dam, and the glacial till in the proposed borrow areas located in the abutments. Twenty-six machine auger borings were made at the locations shown on the Soil Boring Location Map. In addition, hand auger borings were made at inaccessible locations upstream from the centerline of the proposed dam. Depth of drilling varied considerably depending on the location of the boring. In general, the borings in the glacial till were drilled to a depth sufficient to insure the uniformity of the deposit. Borings in the borrow area were drilled below the maximum depth of the proposed borrow excavation.

All borings in the stream valley were drilled to the gray clayey silt glacial till that underlies the alluvium.

Standard penetration tests were performed at selected elevations as the borings progressed. This test is performed by driving a 1 3/8 inch inside--2 inch outside diameter split spoon sampler into the undisturbed soil at the bottom of the drill hole by means of a 140 pound weight falling a distance of 30 inches. The number of blows required to drive this sampler a distance of 12 inches is known as the "N" value of the soil and is recorded on the boring logs. The "N" values are a reliable measure of the relative density of cohesionless soils and can be used to estimate the consistency of cohesive soils.

Samples from the split spoon samplers were placed in glass jars for laboratory tests. Disturbed samples were taken from the borings in the borrow areas.

Undisturbed samples from the alluvium were obtained by pressing 3-inch diameter seamless tube samplers into the undisturbed soil bottom of the drill hole located near Station 12 + 95. These samples were sealed in the field and transported to the laboratory for extrusion and testing.

LABORATORY TESTING

Laboratory tests on samples obtained from the borings included visual descriptions, moisture content determinations, unconfined compression tests, Atterberg limit determinations, Standard Proctor moisture-density tests, and compression tests on compacted samples. All of these tests were performed during September and October by experienced engineers. Results of these tests are summarized in Tables I, II and III, the boring logs, and on the Standard Proctor curves appended to this report. Test data coupled with the field boring logs are used as a basis for delineating and describing the different soil strata encountered at this site.

SOIL CONDITIONS

It is convenient to divide the deposits at this site into three separate groups when describing the subsoil conditions. The three groups include the glacial till in the abutment areas, the alluvium in the stream valley and the glacial till in the borrow area. The glacial till in the abutment area is the same as the till in the borrow area. However, it is convenient to

[illegible] the behavior of the till as an embankment foundation material from the function of the material as a compacted embankment. Specific details pertaining to use of the borrow material will be discussed in a later section of the report.

Soils encountered in the abutment areas consist of very stiff to hard compact glacial till. "N" values from the standard penetration test conducted on these soils range from 14 to 65, and the unconfined compressive strength varies from 5 to 10 tons per square foot. Natural water content ranges from 12 to 15 percent. Near the surface the predominant color is brown, but the color changes gradually with depth, and below a depth of about 25 feet the color is predominantly gray. Throughout the profile this till is characterized by the presence of coarse sand grains and small pebbles. Grain size tests on four representative samples of this material are shown in Table I. Nearly all of the soil passes the Number 10 sieve, and more than 70 percent passes the Number 200 sieve. Grain size tests on the four samples from the borrow areas (also shown in Table I) indicate the same grain size distribution for the glacial till in the borrow area near the south abutment.

The variable character of the alluvium in the stream is indicated on the soil profile shown in Figure 1 and on the individual boring logs. A layer of stratified gray silt clay and clayey silt was encountered near the ground surface [illegible] of the borings. The thickness of this layer varied from [illegible] at boring 9 + 00 to 25 feet in the vicinity of boring 13 + 50.

The shear strength of this cohesive material ranges from 1.7 to 4.0 tons per square foot with an average of about 3.0 tons per square foot. In general, the natural moisture content of this layer increases with depth. The range in water content is 10 to 30 percent with most of the values lying within the range of 15 to 25 percent. This relatively wide range in moisture contents is caused by desiccation of the upper portion of the layer and by the presence of silty or sandy lenses in the test specimens. "N" values for tests performed in this strata range from 2 to 11 and the average is about 6. Horizontal stratification of the sediments is more pronounced in the lower portion of this strata. Such a stratification indicates that the permeability in the horizontal direction is greater than in the vertical direction. Since the soil in this layer is predominantly fine grained it is obvious that the permeability will be quite low except in the strata which contain appreciable portions of sand. One undisturbed sample was taken from the upper layer at Station 12 + 96. The sample was recovered from a depth of 6 feet. The unconfined compressive strength of this sample was 0.78 tons per square foot, and the natural water content was 24.3 percent. Liquid limit of the sample was 32, and the plastic limit was 20. This sample is classified as an inorganic clay of low plasticity, CL, according to the Unified Soil Classification System. The fact that the natural water content is closer to the plastic limit than the liquid limit indicates that this layer has been preconsolidated by a stress in excess of the one which exists at the present time.

The strata underlying the layer described in the previous paragraph consists of gray silty sand. Most of the logs indicate the grain size increases with depth, and in some holes the sand varied from fine near the top of the layer to coarse near the bottom. There is some evidence of stratification in this strata. The permeability of the sandy alluvium is sufficient to cause seepage losses beneath the dam as well as giving rise to the danger of piping due to seepage. Grain size determinations on samples of the sand indicate that this material would be classified as silty sand, SM. There was an appreciable silt content in most of the samples obtained from this sandy layer. Thickness of the sand layer varies from a few feet near the north abutment to a maximum of 25 feet at Station 13 + 00.

All of the alluvial sediments in the valley bottom are underlain by a strata of gray clayey silt which contains some coarse sand and pebbles. This stiff cohesive material is of glacial origin and is similar to the glacial till of the abutment and borrow areas. The distance from ground surface to the top of this impermeable strata is about 32 feet between Stations 7 + 00 and 12 + 00. Between 12 + 00 and 13 + 50 the average depth to the glacial till is variable and reaches a maximum of 45 feet in the vicinity of Station 13 + 50.

In addition to the primary strata that have been described several distinct minor lenses or strata were encountered in several of the borings. In general these layers were [illegible] limited in size in a lateral direction but were more continuous between [illegible]

the fact that the sediments in the valley are variable and that they may vary considerably from point to point in the profile.

Borings made both upstream and downstream from the centerline of the proposed dam are quite similar to the series of borings made along the centerline.

Ground water level in the valley bottom varies from 10 to 15 feet below the ground surface. Average depth to the free water was about 13 feet when the borings were made during the month of August. It is anticipated that this water level will be encountered at somewhat higher elevations during the wet season of the year. Excavation of a cut-off trench below the water table will require special de-watering considerations in order to maintain stability of the slopes during construction operations.

It has been noted already that the subsoil in the borrow areas is essentially the same as that in the abutment areas. Two separate borrow areas were investigated in the course of this investigation. A total of four borings were drilled in the area south of the dam. These borings are designated 1 through 4, and the location is indicated on the Soil Boring Location Map. Borings 5, 6, 7 and O-372 were drilled in the borrow area at the north abutment. A large representative sample of the soil encountered in each hole was tested in the laboratory. The results of the tests are summarized in Tables I

II, and III and on the Standard Proctor curves.

The results of the Atterberg Limit tests and grain size determinations indicate that the physical properties of the glacial till are quite uniform. The range in liquid limit is from 29 to 43 with an average of about 35. All of the samples tested are classified as CL, inorganic clays of low to medium plasticity, according to the Unified Soil Classification.

It is noted that the average optimum moisture content at the south area is several percent lower than the north area, and the maximum dry density in the south area is about 5 pounds per cubic foot greater than the samples from the north area. This difference in moisture-density values may be attributed to the fact that the borings in the south area were nearly 45 feet deep whereas all of the borings in the north area were terminated at a depth of 25 feet. This fact that the samples in the north area are from a shallower depth may give an explanation for the somewhat higher liquid limit values for samples from borings 5 and 6.

Several water bearing sand or silty sand pockets were encountered in the borings. Pockets of this type are typical of glacial till deposits. They may range from a few inches to several feet in size and may occur at random locations in rather irregular shapes. If extensive sand lenses are encountered during construction, it will be necessary to waste this permeable material or place it at the outer edge of the fill in such a manner that seepage through the dam will not occur.

A series of tests were performed on undisturbed compacted samples of the borrow material to measure the unconfined compressive strength of the soil when compacted at different water contents. The results of these tests are summarized in Table XII. The percent compaction reported in this table is the relationship between the dry density of the unconfined compression test sample and the maximum dry density at optimum moisture content. An inspection of this data indicates that it is possible to obtain more than 95 percent of standard proctor maximum density for a wide range of moisture contents. The effect of variations in moisture content on the shear strength is a more critical feature, and therefore careful consideration of this item is essential. It should be noted that the maximum shear strength was obtained at a water content slightly less than that associated with the maximum dry density. Also it is noted that a noticeable reduction in shear strength occurs as the moisture content is increased above that required for maximum density.

Placing of material dry of optimum is undesirable because of the danger of low density, increased permeability and excessive softening and settlement on saturation by the reservoir resulting in possible cracking of the fill. The moisture content should not be appreciably greater than optimum for Proctor maximum density because of the difficulty in placing, subsequent settlement and durability due to the lower shear strength. These considerations lead to the conclusion that it is most desirable to place

the material close to the optimum moisture content at Proctor maximum dry density. A range of ± 2 percent from this optimum value appears to be reasonable for the borrow material proposed for this homogenous dam.

TREATMENT OF EMBANKMENT FOUNDATION

The permeable stratified sediments in the stream valley require special consideration in order to insure that the seepage losses beneath the dam are not excessive and the danger of a piping failure is eliminated. Several methods of intercepting the seepage beneath the dam have been considered by the writer and the consulting engineers. Among these methods are a cut-off trench, a partial cut-off trench, sheet piling, grouting and the use of an upstream blanket. The two most favorable treatments from a cost standpoint are the use of a cut-off wall or an upstream blanket. The most positive method of controlling the amount of seepage beneath the dam and insuring that no difficulty will be encountered due to piping through the foundation or by uplift pressures at the toe is by the installation of an impervious cut-off trench from the existing ground surface to the impermeable glacial till which underlies the alluvium. Use of a drainage blanket upstream from the dam would not be as satisfactory as a cut-off trench because of danger of leaks in the blanket and because of the amount of stripping and material required for a satisfactory cover.

The relatively high water table coupled with the

permeability of the alluvium requires that a well point dewatering system be installed to lower the water table during construction. The water table must be lowered in order to maintain stability of the slopes and to insure that the rolled fill in the core trench will be constructed in the dry. A single stage of well points is capable of lowering the water table about 15 feet. It will be necessary to lower the water table nearly 30 feet throughout most of the trench, and in the area from Station 12 + 0 to 13 + 50 it will be necessary to lower the water table in excess of 40 feet. In order to accomplish the dewatering required it will be necessary to use a multiple stage well point installation where separate rows of well points are driven from benches cut in the side slopes of the core trench. The vertical distance between these benches should not exceed 15 feet, and it would be desirable to limit this distance to 13 feet. The benches should be at least 6 feet wide, and a slope of 0.5 feet horizontal to 1 foot vertical is considered satisfactory because this will result in an average slope of about 1 foot horizontal to 1 foot vertical for the entire depth of the excavation.

The dewatering operation will cause some consolidation of the loose sediments and will cause an increase in effective stress in the foundation material. These two factors also will contribute to the stability of the excavation slopes. The width of the core trench should be at least 10 feet to provide a positive barrier, and the bottom of the cut-off wall should extend at least 2 feet into the impermeable glacial till. The centerline of the bottom of the core trench should be about

[illegible] least upstream from the centerline of the dam and should parallel the dam across the main portion of the valley. In the abutment areas a key trench should be provided to insure a water tight bond between the rolled fill and the natural ground.

The material excavated from the core trench can be used as a stabilizing fill on the lower portions of the slopes of the rolled fill dam. It may be possible to use some of the granular material from the trench for the pervious toe drain required in the embankment. A decision concerning the use of this material cannot be made until the excavation has advanced to the point where careful inspection and grain size determinations can be made on representative samples of the material.

EMBANKMENT CONSIDERATIONS

There are several factors that must be considered in the evaluation of the slopes selected for the rolled homogenous dam. Among these are the shear strength of the compacted fill, the shear strength of the foundation, and the seepage through the embankment.

Shear strength determinations on the compacted specimens indicate that an upstream slope of 3:1 and a downstream slope of 2½:1 is satisfactory provided that the dam is not subject to a drawdown rate of more than 6 feet per day after the maximum reservoir level has been maintained for a sufficient length of time to saturate the embankment.

Foundation material beneath this proposed dam has an average "N" value between 4 and 10, and as a result the consistency of the material would be classified as medium. An increase in the overall safety can be accomplished by using the excess of material excavated from the core trench as a stabilizing fill or toe berm on the lower portions of the embankment. This stabilizing fill will be used to provide weight only and consequently, no special methods of construction or compaction requirements are needed for the placement of this material. Use of the excavated material for this purpose will provide for a satisfactory method of disposing of this waste material.

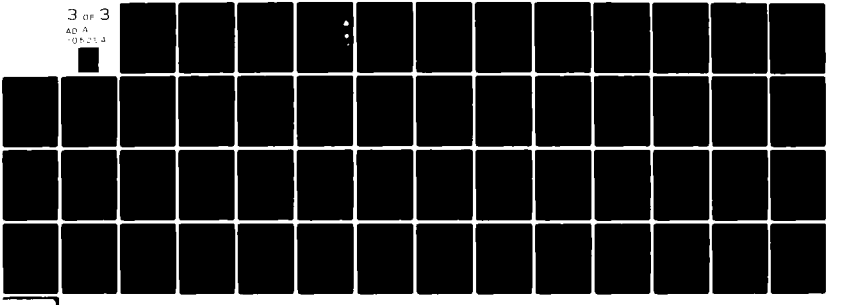
It is anticipated that some settlement of the embankment will occur due to the consolidation of the alluvium as the result of the increase in stress due to the embankment. Because of the permeable nature of the silty sand, most of the consolidation will occur during the construction of the embankment, and very little settlement due to consolidation of the foundation will occur after the embankment is completed. It is estimated that the total settlement due to consolidation in the foundation during construction will not exceed one foot. Also it is anticipated that another foot of settlement will occur within the compacted embankment even though the placement moisture and compaction procedures are carefully controlled. A major portion of the embankment consolidation also will occur during the construction operations.

Even though the embankment will be constructed of carefully compacted cohesive material, there will be some seepage through the embankment. It will take some time for the seepage through the dam to reach a steady state of flow. This steady state condition which determines the phreatic surface of seepage through the dam will establish the maximum saturation of the embankment and is the most critical post-construction condition for the stability of the downstream slope. If the phreatic surface intercepts the slope above the base of the dam a general softening of the fill will occur, and as a result the stability of the slope may become critical. In order to maintain the stability of the downstream slope it is essential that a toe drain be installed to intercept the flow through the embankment in such a manner that the phreatic surface is kept well within the compacted embankment.

The toe drain can consist of a filter drain that starts at the downstream toe of the embankment and extends upstream to a point about 60 feet from the centerline of the dam. This toe drain should be extended across the valley and up the abutments to the maximum storage elevation. The minimum thickness of the toe drain should not be less than 2 feet. A perforated pipe underdrain should be installed in a trench about 20 feet upstream from the toe of the dam to collect the water from the toe drain.

A satisfactory alternate to the toe drain would be

AD-A105 254 HOSKINS-WESTERN-SONDEREGGER INC LINCOLN NE F/G 13/13
NATIONAL DAM SAFETY PROGRAM. LAKE THUNDERHEAD DAM (MO 10007), G--ETC(U)
MAY 80 R S DECKER, G JAMISON, G ULMER DACW43-80-C-0071
UNCLASSIFIED NL



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the installation of a strip drain within the embankment. This drain should have a cross section of 6 x 12 feet across the main valley and 4 x 12 feet in the abutment areas. Granular discharges having dimensions of 4 x 6 feet should be spaced at about 100 foot centers and should extend from the strip drain to the downstream slope. The centerline of this strip drain should be located about 60 feet downstream from the axis of the dam. It is believed that the use of a strip drain would result in a saving of granular material but would require some extra effort during construction.

Several other features of the embankment design such as crest width, freeboard, upstream slope protection, downstream slope protection and surface drainage have an effect on the stability of the embankment. Since these features require considerations other than soils, they are considered to be beyond the scope of this report.

Grain Size Data

Boring No.	Depth	Percentage Passing #10	#40	#200	Unified Classification
14 + 73	10'	94.5	88.5	70.2	CL
16 + 25	10'	97.7	93.0	73.5	CL
3 + 35	5'	99.8	96.6	78.6	CL
5 + 58	10'	99.8	97.7	72.8	CL
12 + 96	12'	100	96.9	41.9	SM
12 + 96	18'	99.9	98.5	33.7	SM
1		99.0	90.2	63.0	CL
2		97.8	91.6	70.0	CL
3		99.4	91.4	70.2	CL
4		99.6	95.3	76.0	CL

Table I

Summary of Test [illegible]

Sample Number	Liquid Limit	Plastic Limit	Classification	Optimum Moisture (Percent)	Maximum Dry Density P.C.F.
1	30	13	CL	12.3	118.3
2	36	15	CL	15.1	112.8
3	35	14	CL	12.8	116.8 So.
4	33	14	CL	12.3	118.2
5	40	15	CL	15.9	110.6
6	43	15	CL	17.4	111.3 No.
7	36	15	CL	16.0	110.8
0-372	29	14	CL	12.6	121.3
				8. 114.4	8 910.1
			Ave	14.3	113.7

Table II

Borings 5, 6, 7 - 0-372 in Borrow Area North.

Ave optimum Moisture = 15.5 %

Ave Mod. Density = 111.0 pcf.

Borings 1, 2, 3, 4 in Borrow Area South

Ave optimum Moisture = 13.1 %

Ave Mod. Density = 116.5 pcf

Summary of Test Data

Selected Compacted Samples

Borrow Sample No.	Moisture Content w, %	Compressive Strength q_u, tsf	Percent Compaction
1	8.0	2.73	
	8.5	4.56	
	9.8	4.93	
	12.6	3.61	
	14.5	2.10	
2	9.9	4.56	96.0
	13.7	2.69	97.7
	15.9	2.55	100.0
	20.2	1.28	94.4
3	10.9	2.62	95.2
	13.1	3.84	100.0
	16.8	1.88	95.5
4	9.6	4.20	94.7
	12.2	3.80	99.7
	14.6	2.30	98.5
	17.0	1.45	95.1
5	11.0	3.95	97.0
	13.4	3.0	98.8
	16.1	2.10	100.0
	19.4	1.08	97.0
6	12.0	4.13	95.9
	15.0	3.50	98.8
	17.8	2.20	99.6
	19.9	1.15	95.7
7	11.5	2.2	94.7
	13.8	2.6	99.3
	17.0	2.76	97.6
	18.9	1.45	98.2
0-372	11.9	4.2	99.9
	15.4	2.35	99.3
	17.9	1.3	97.9

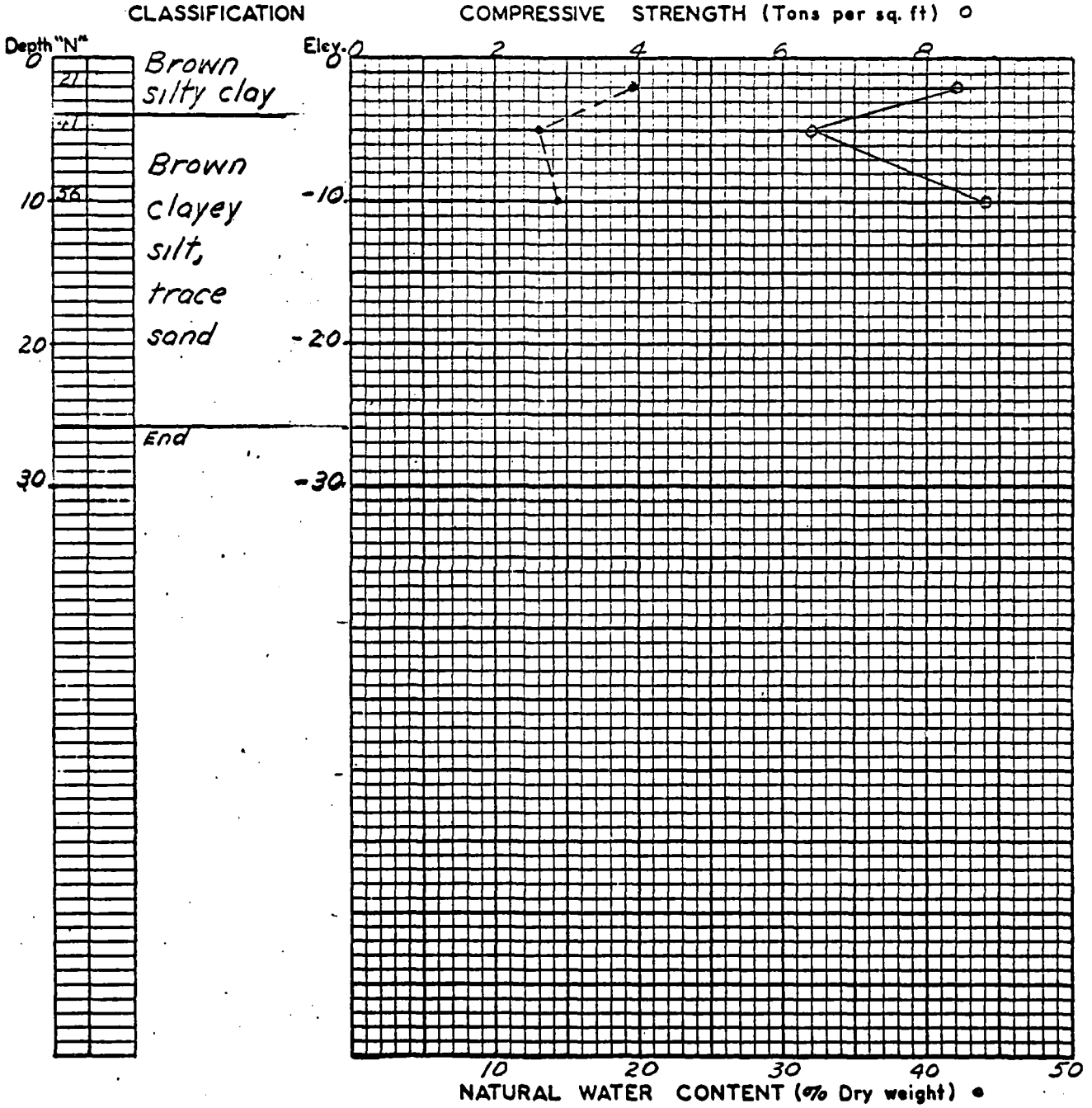
Table III

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE OCT 1964

BORING NO. 3+35



Date of boring: Started Aug 27 1964 Finished _____ Date of tests Oct. 3 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by TSF

Remarks _____

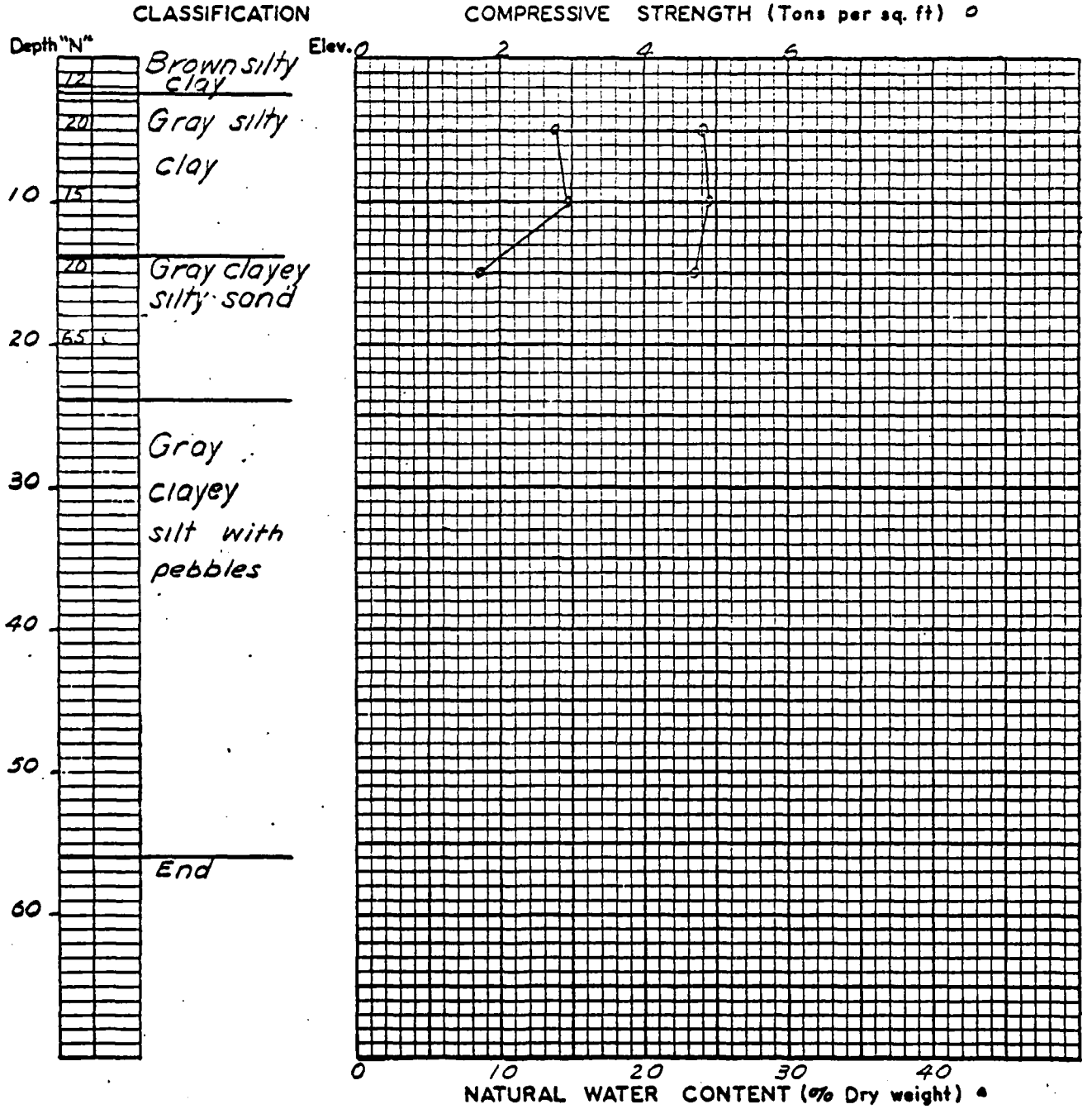
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION Putnam County Lake DATE Oct 1964

BORING NO. S-5B



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

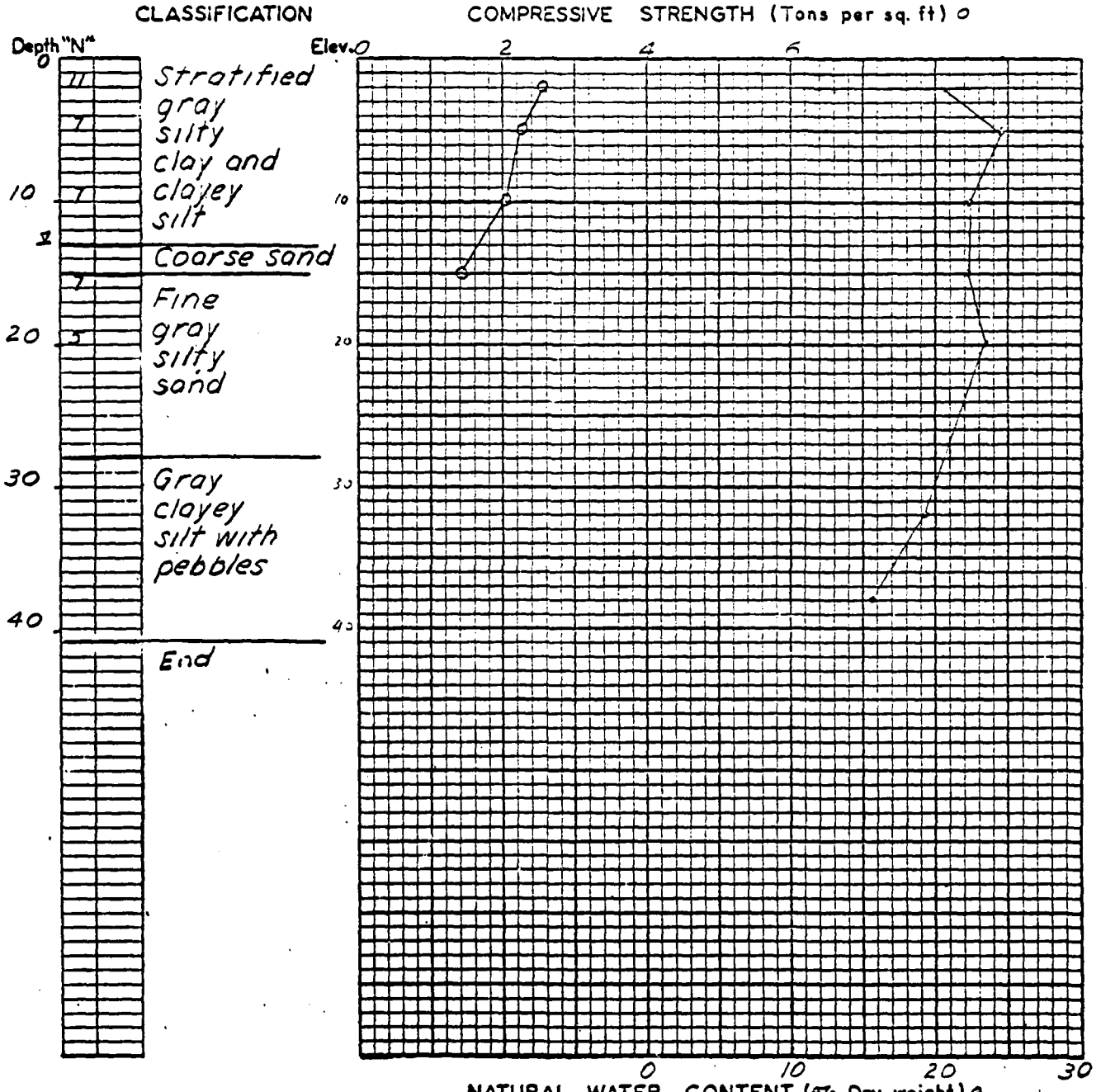
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE OCT 1964

BORING NO. 7+00



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

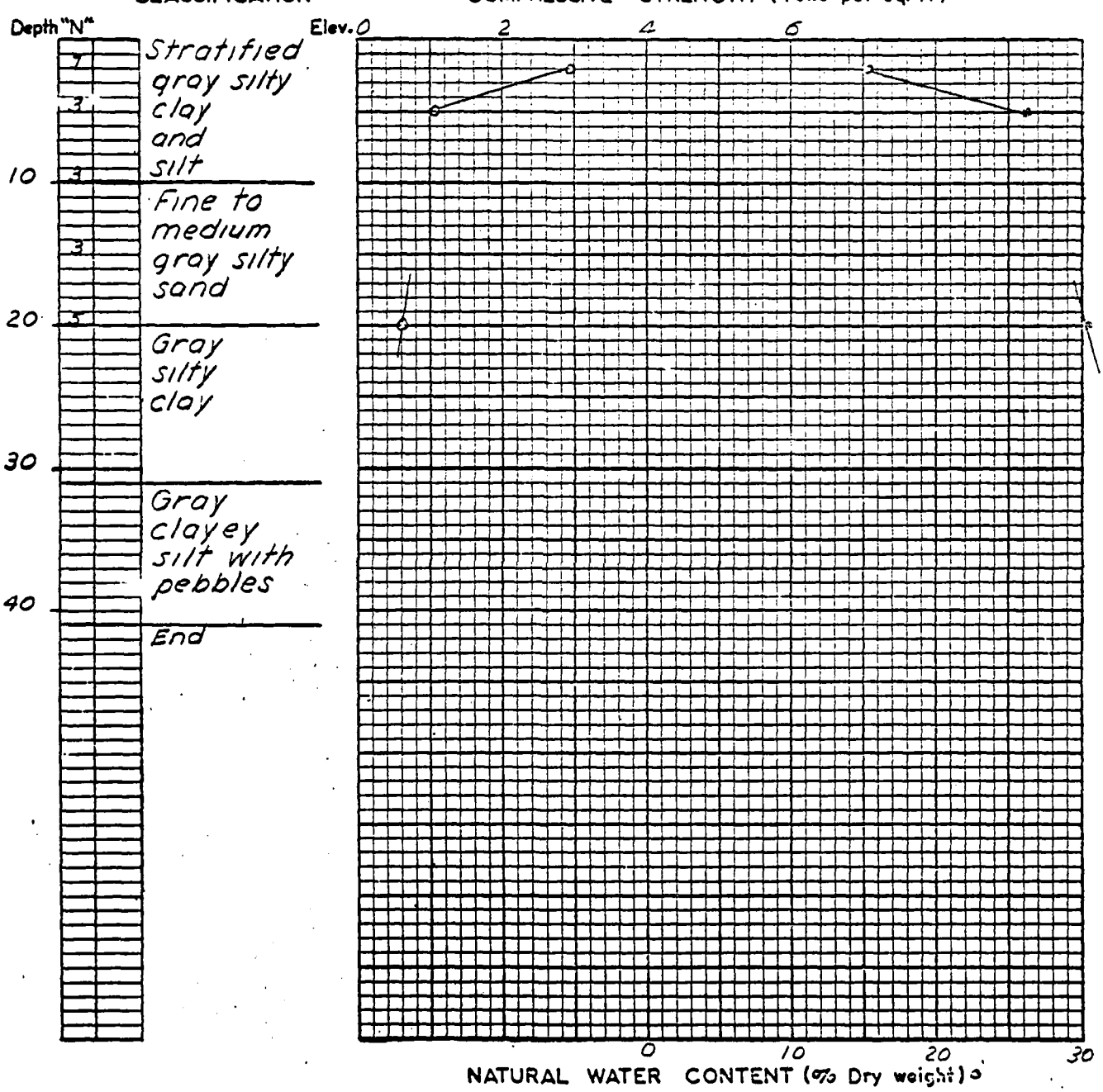
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE OCT 1964

BORING NO. 9+00



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

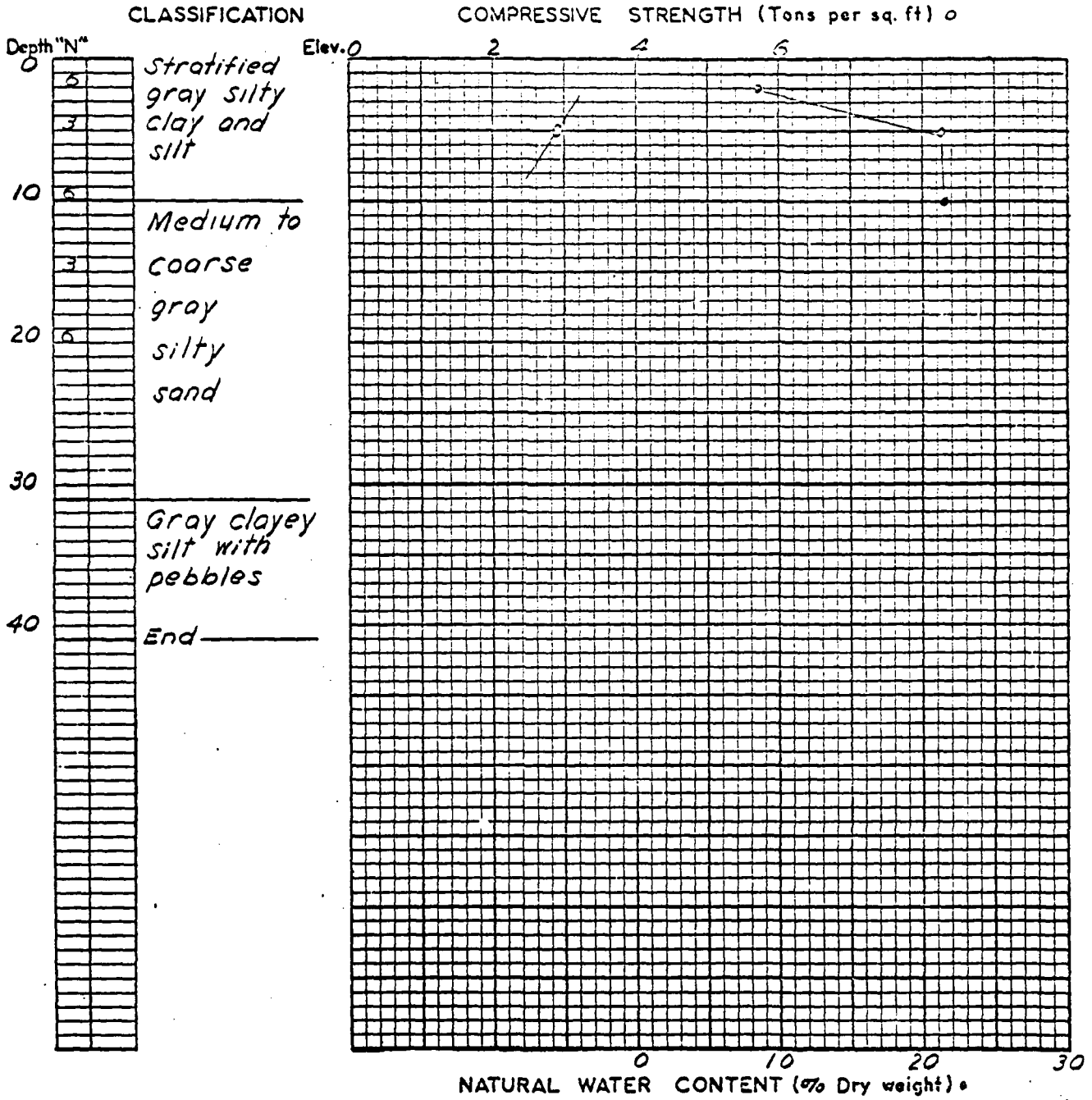
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE OCT 1964

BORING NO. 10+00



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

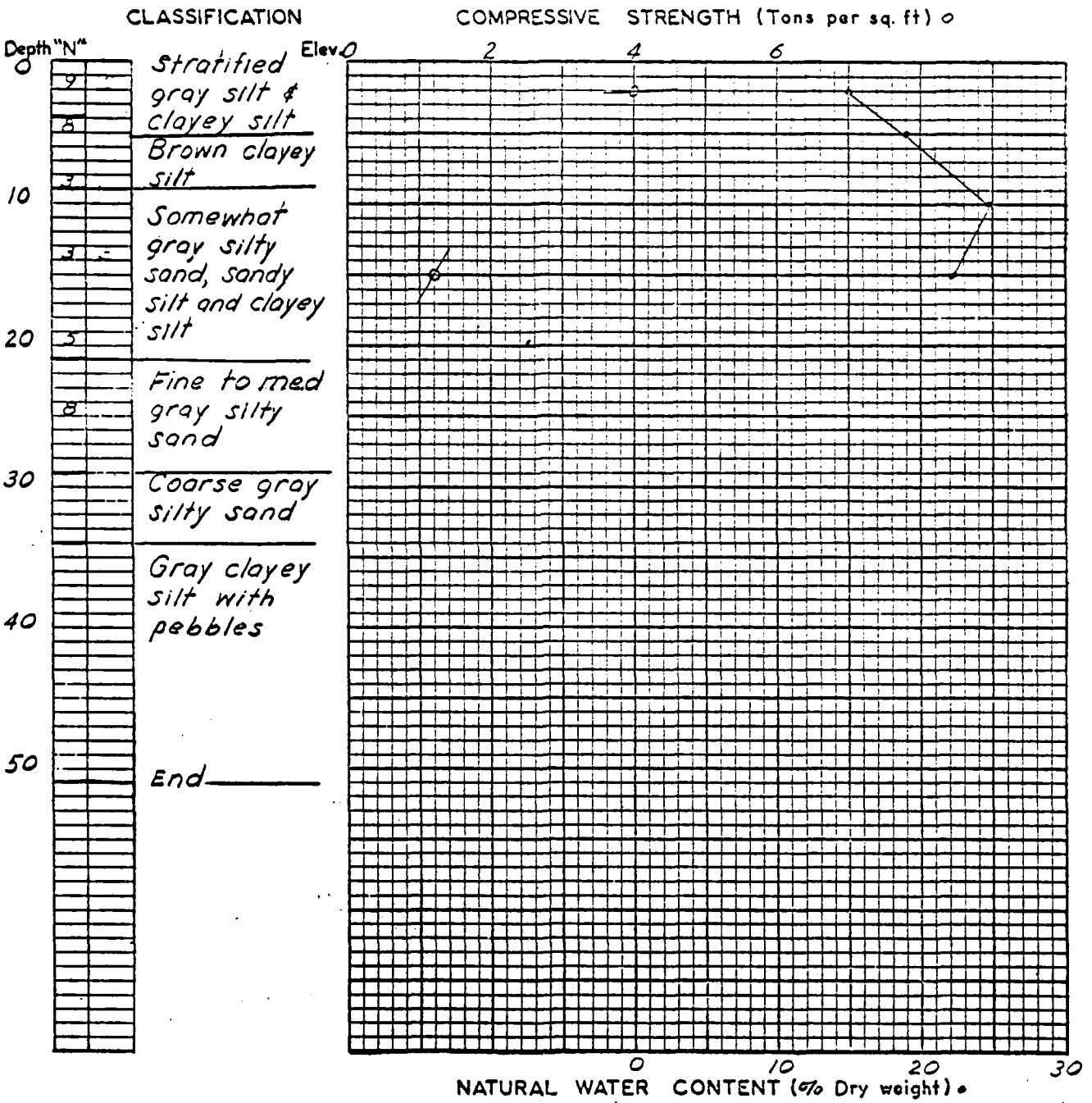
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE OCT 1964

BORING NO. 11-20



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

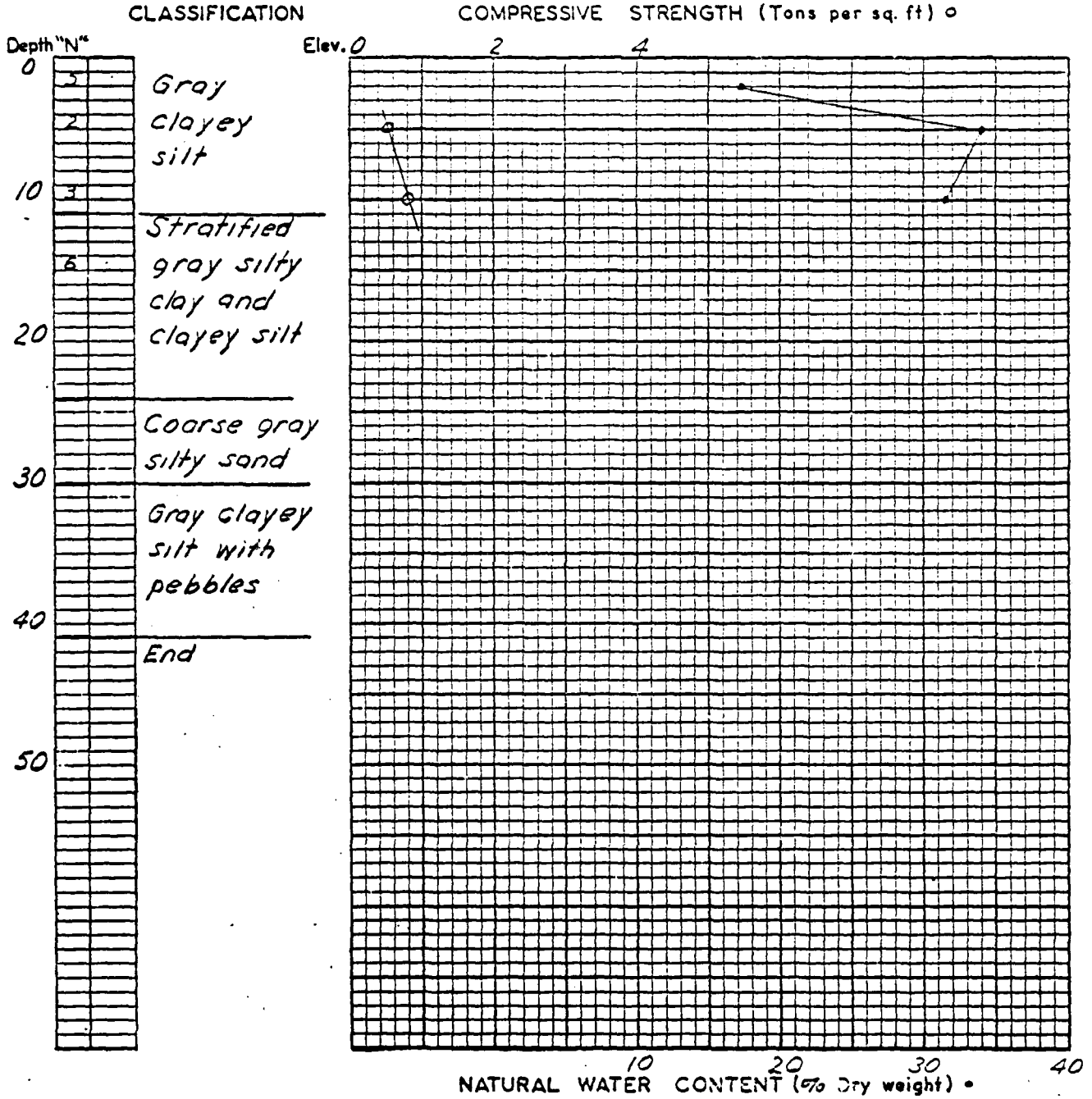
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 12+00



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

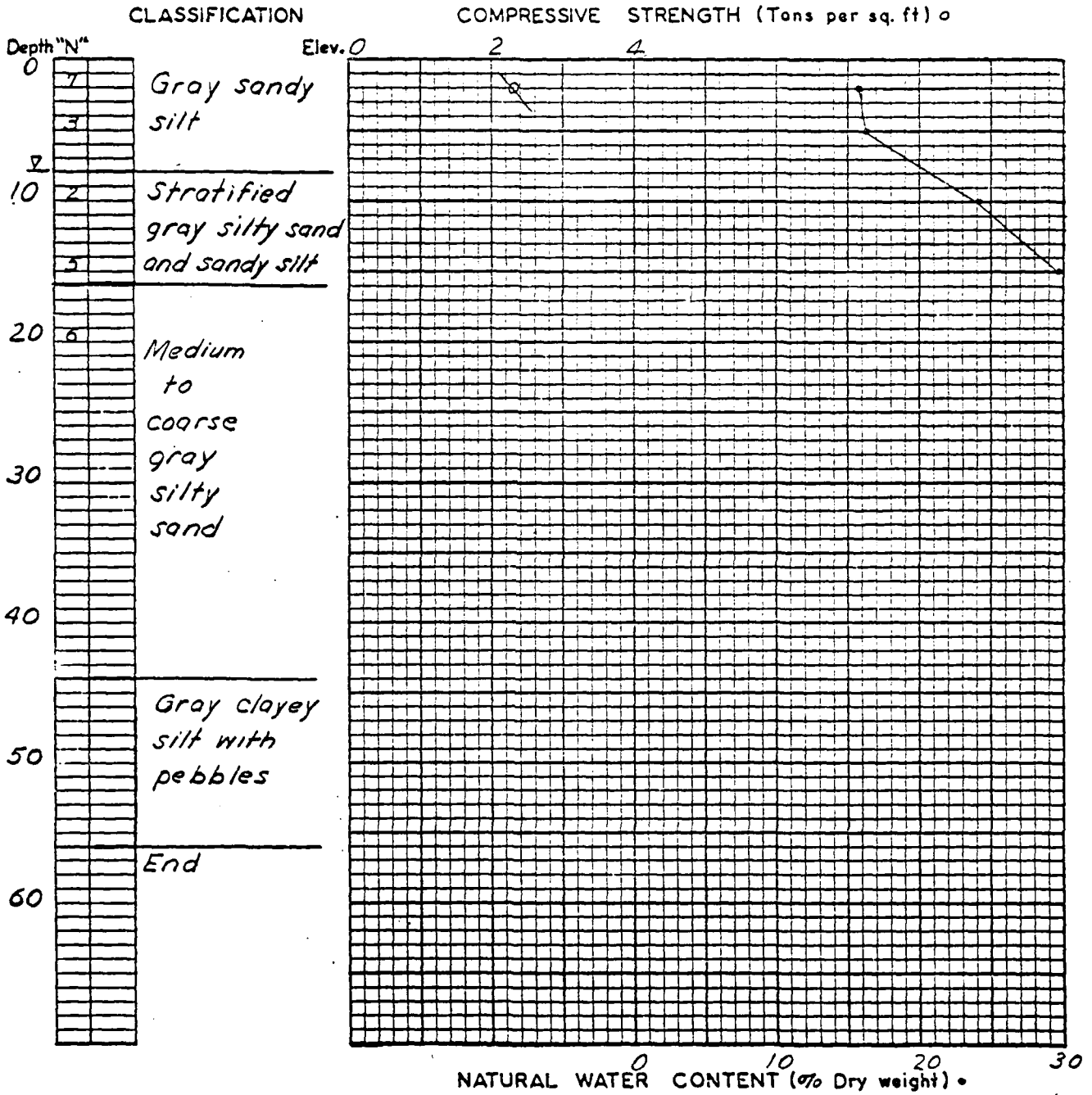
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 12+53



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

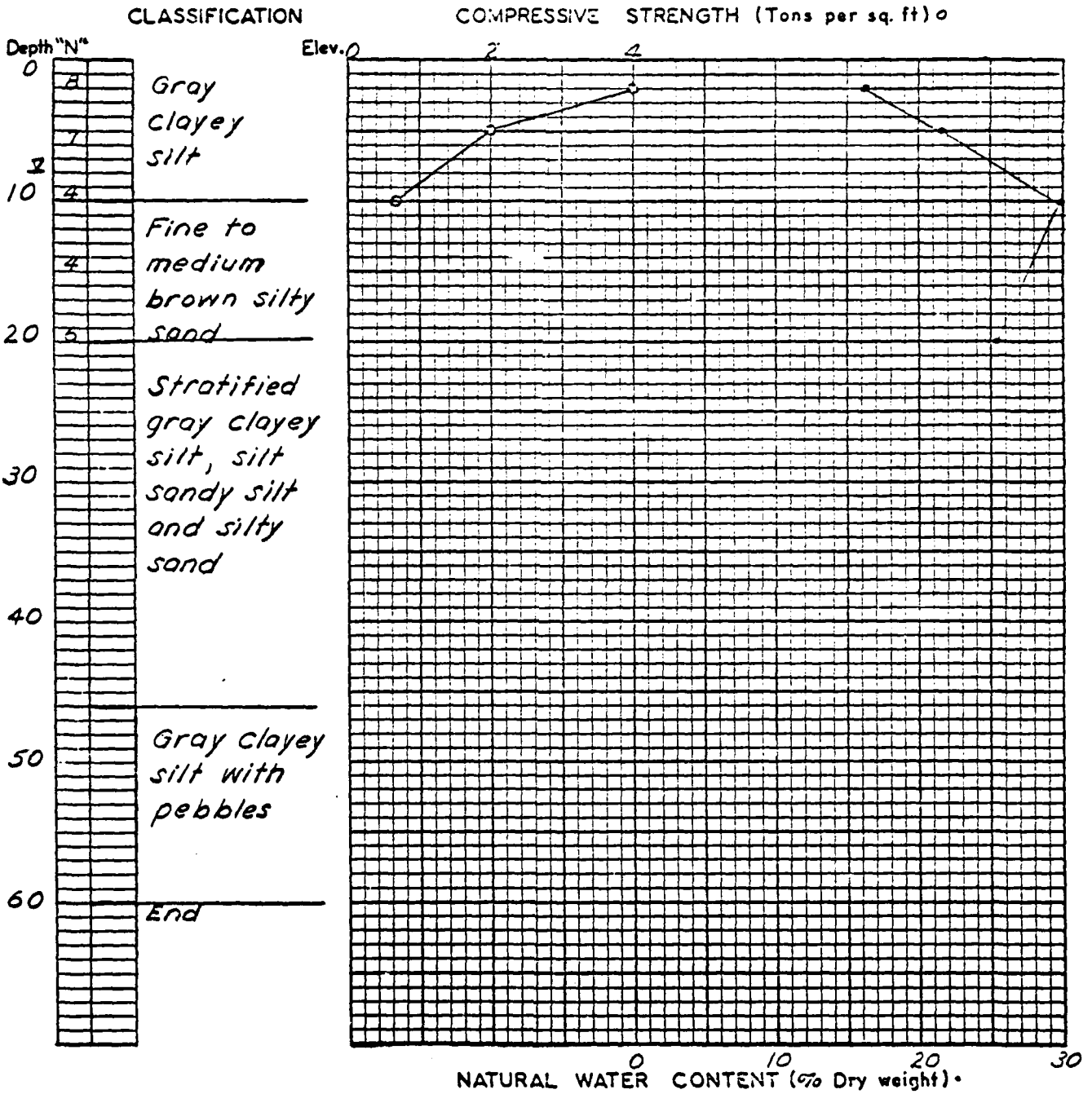
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 13+06



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

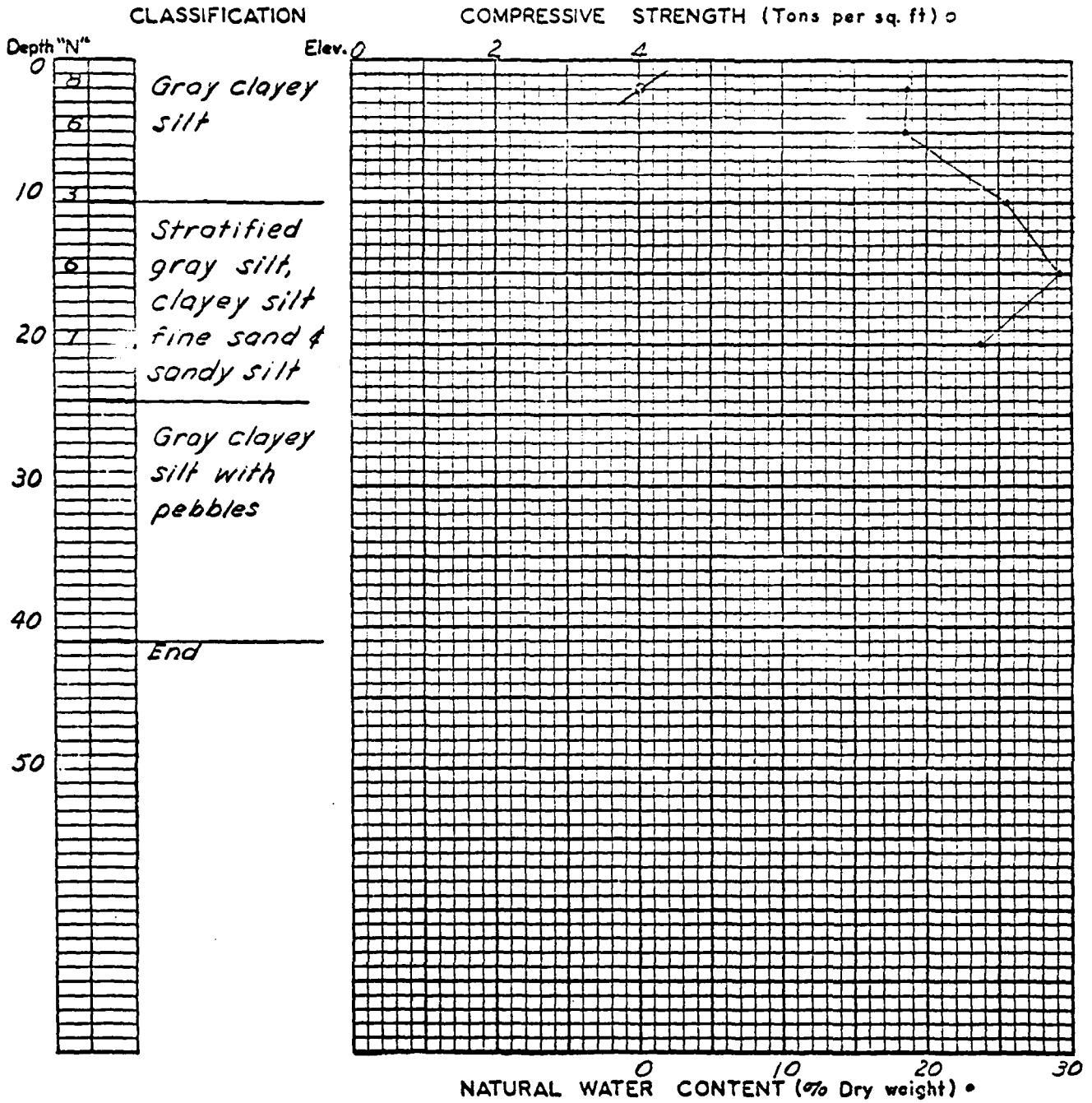
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 13+50



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

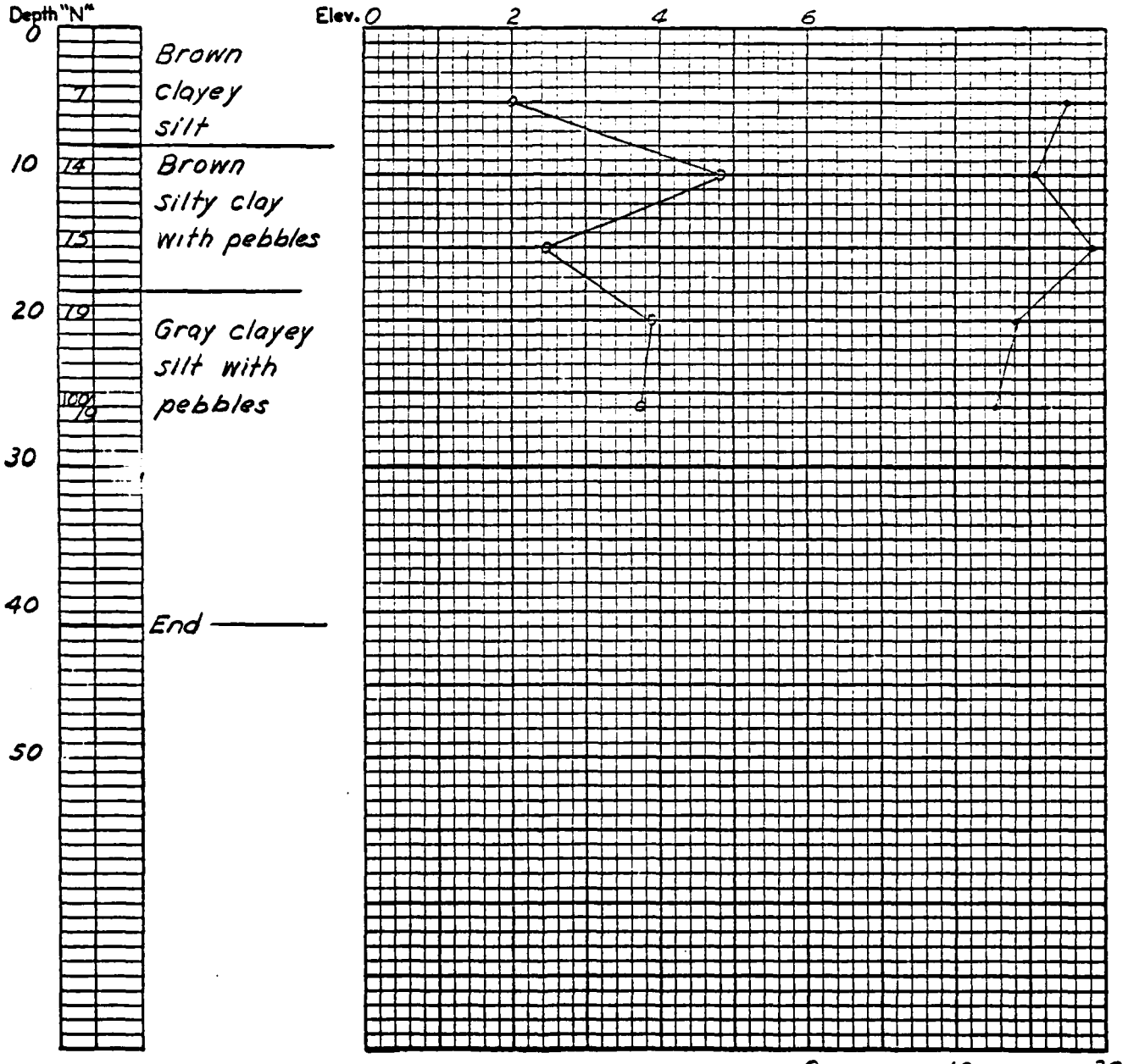
TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 14+00

CLASSIFICATION

COMPRESSIVE STRENGTH (Tons per sq. ft) o



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

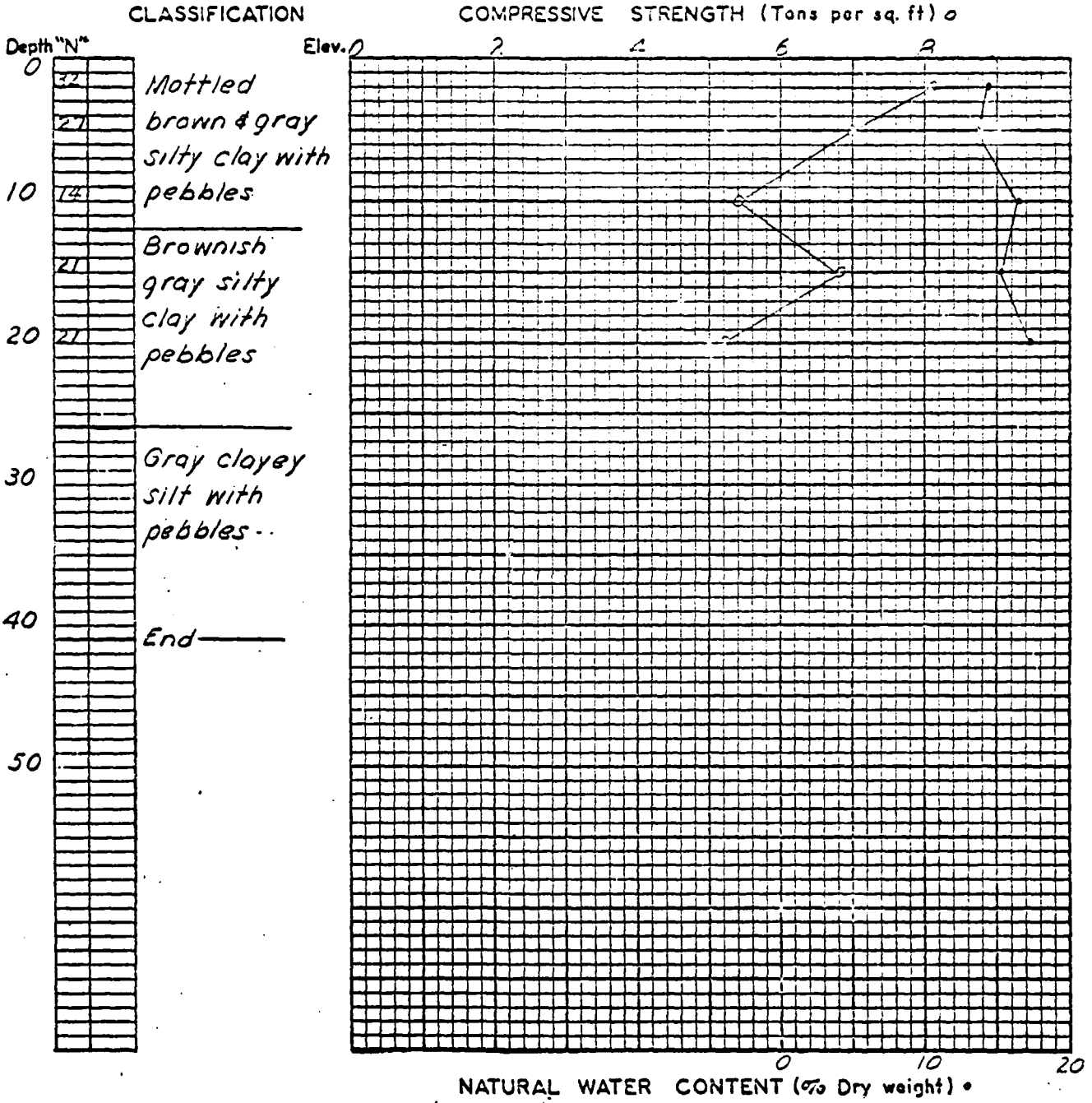
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 14+72



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

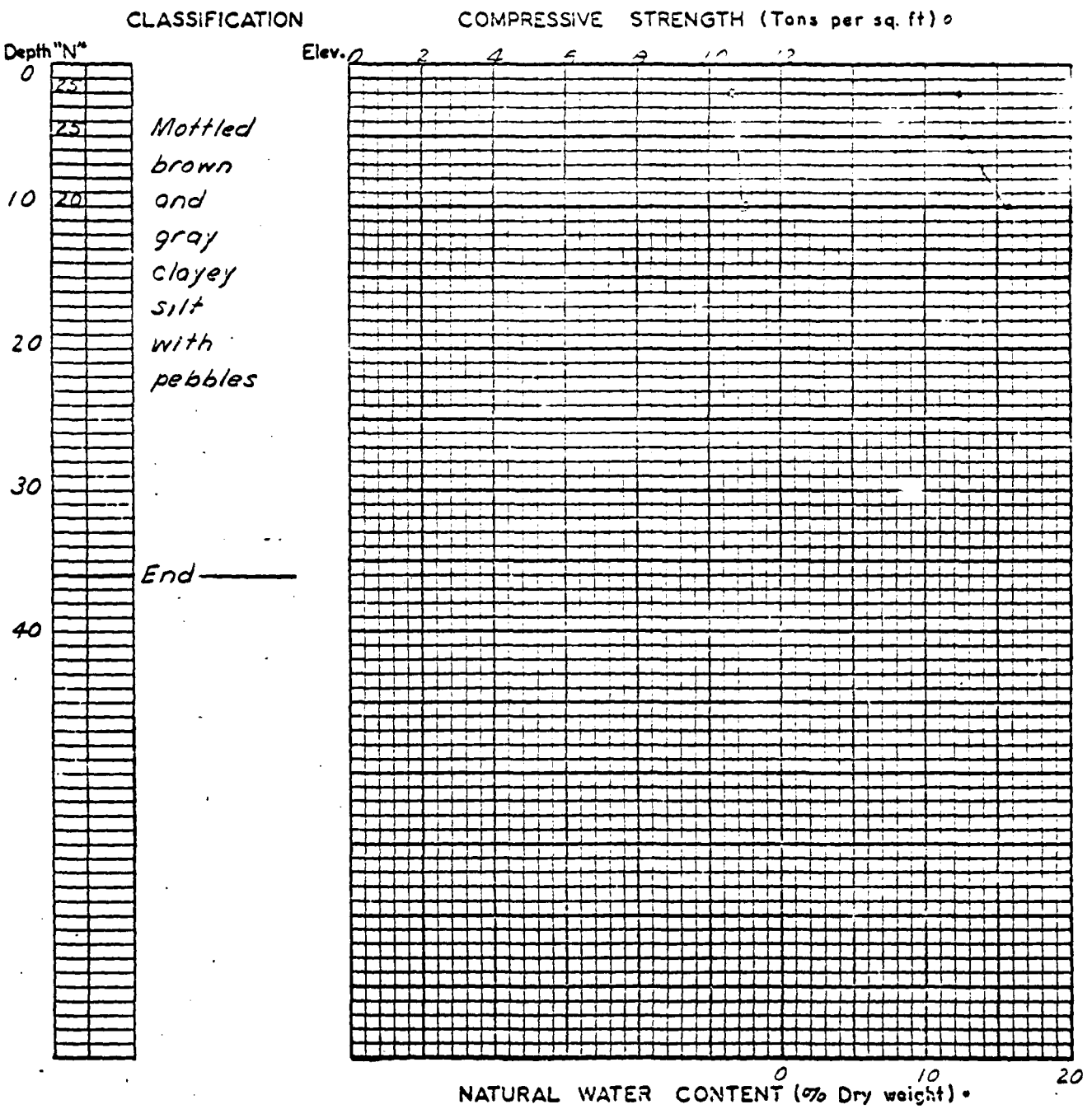
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 1A-2-E



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

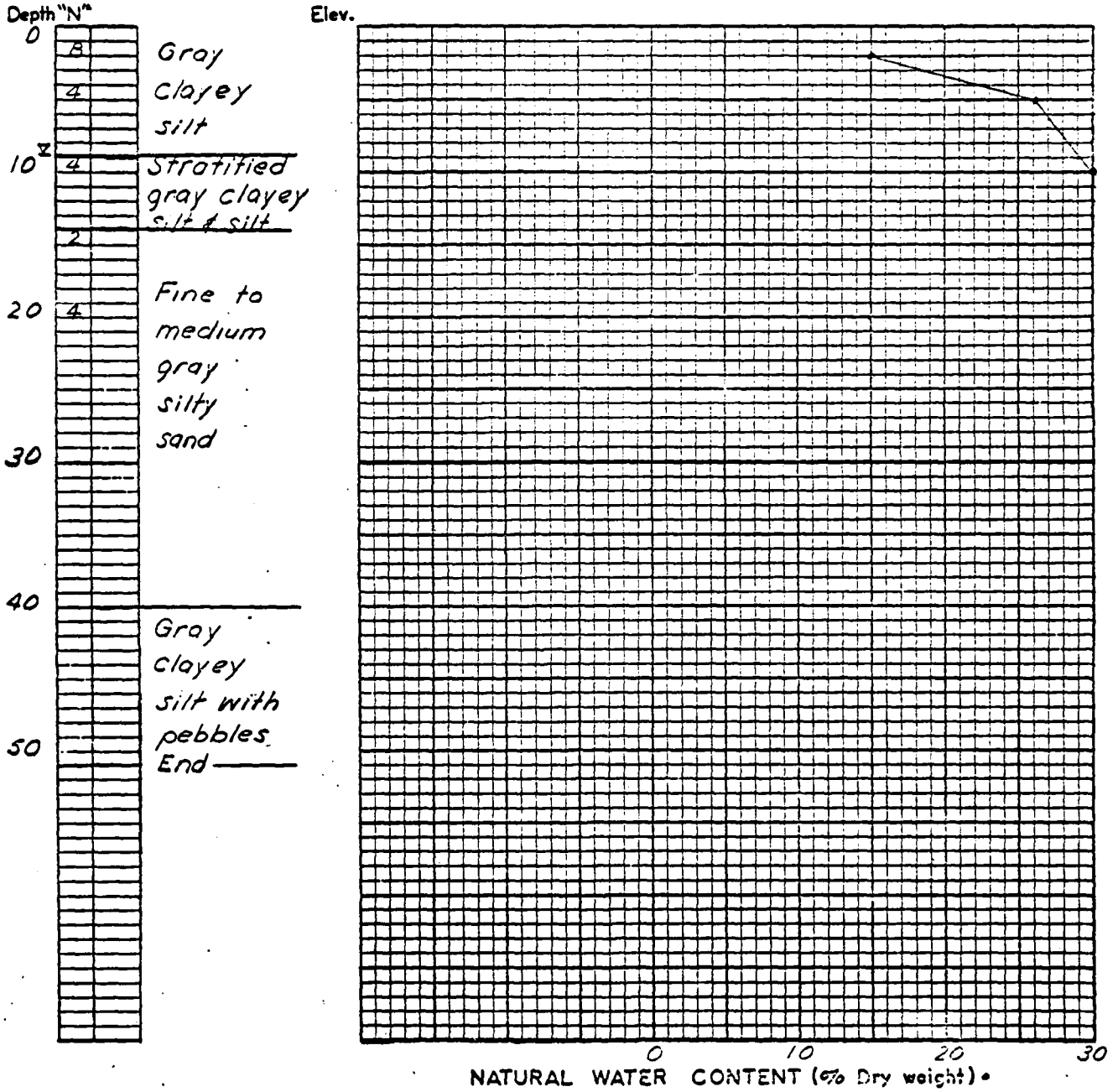
TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. A

CLASSIFICATION

COMPRESSIVE STRENGTH (Tons per sq. ft)



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification _____

Remarks _____

FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

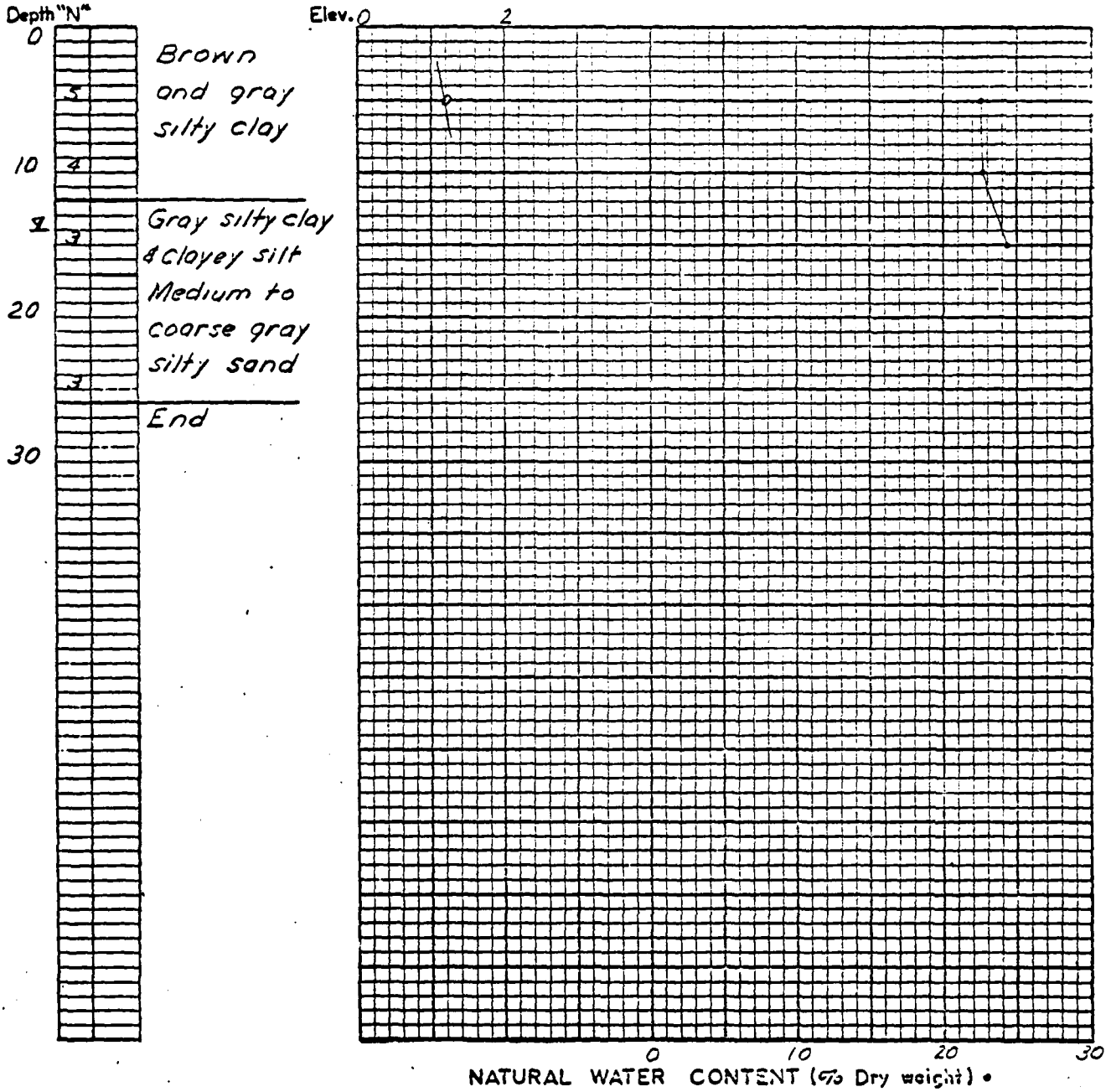
TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. L. Fork

CLASSIFICATION

COMPRESSIVE STRENGTH (Tons per sq. ft) o



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Mechine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

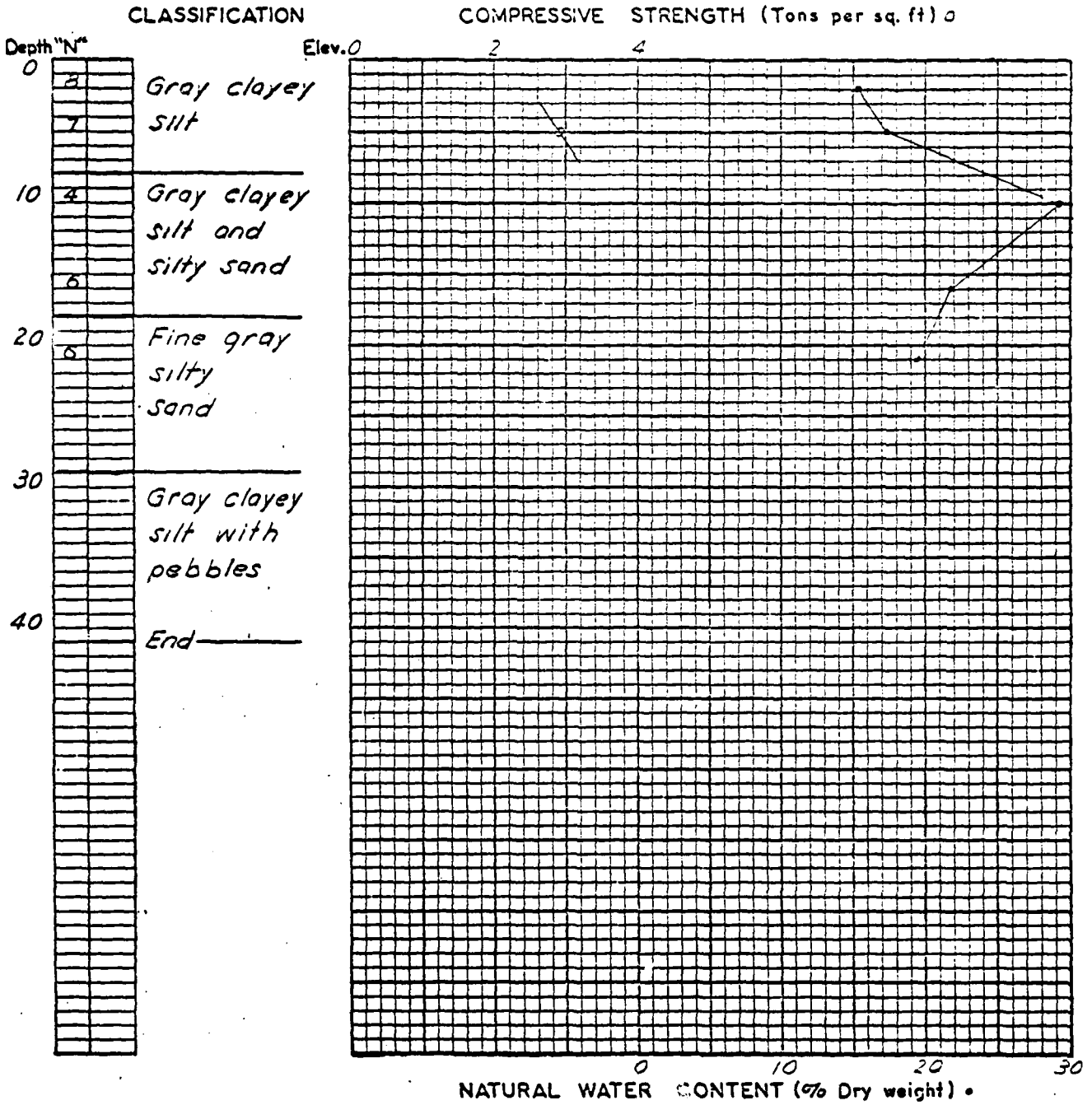
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 3



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct 1964

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

Boring Contractor _____ Foreman _____

Classification by _____

Remarks _____

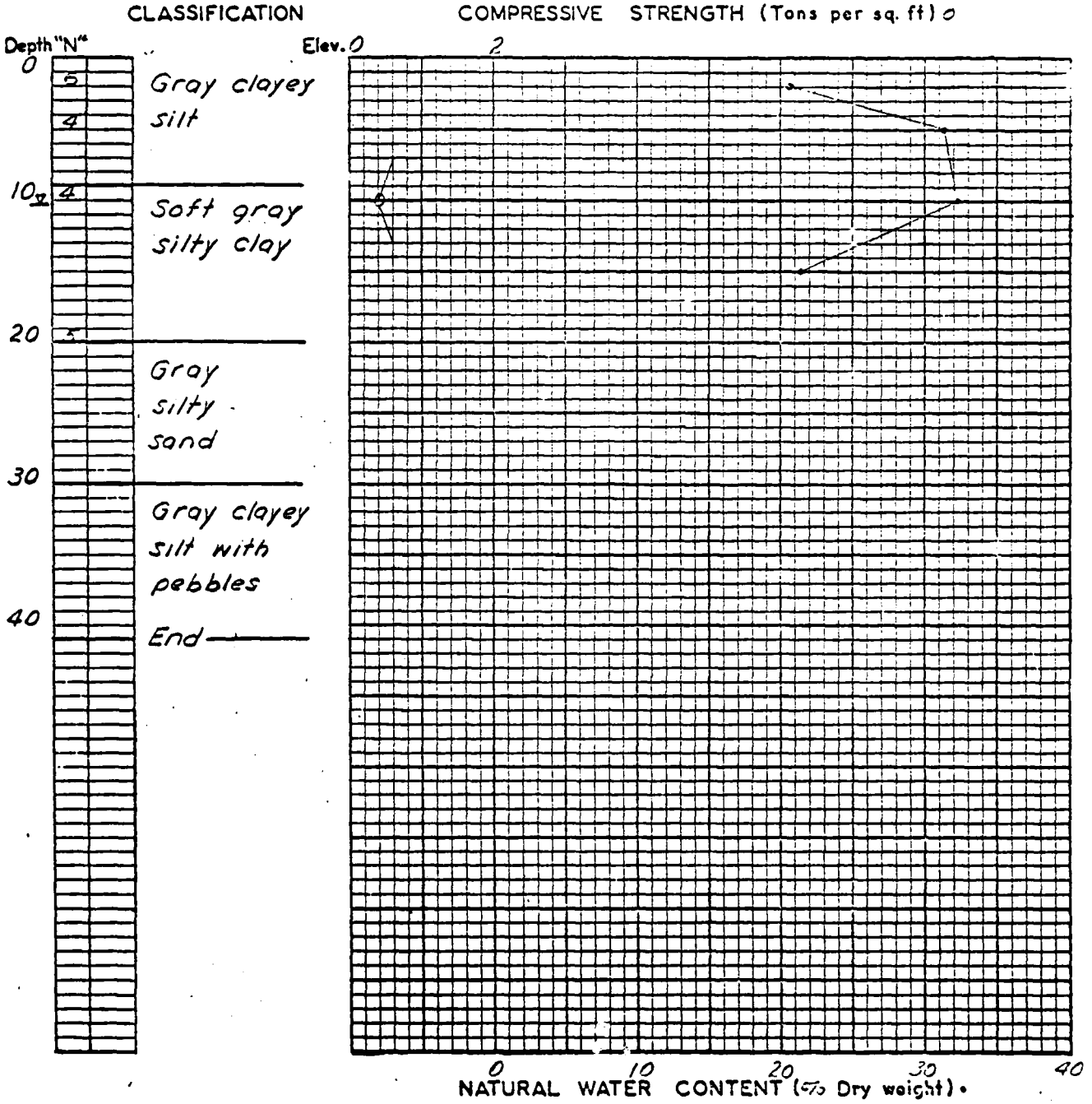
FIGURE NO. _____

THOMAS S. FRY PH.D
CONSULTING ENGINEER

TEST BORING DATA

JOB NO. _____ LOCATION PUTNAM COUNTY LAKE DATE Oct 1964

BORING NO. 9



Date of boring: Started Aug 1964 Finished _____ Date of tests Oct

Type of drilling Machine Auger Sampling tools used Split Spoon

Size and depth of casing _____ Fixed datum used _____

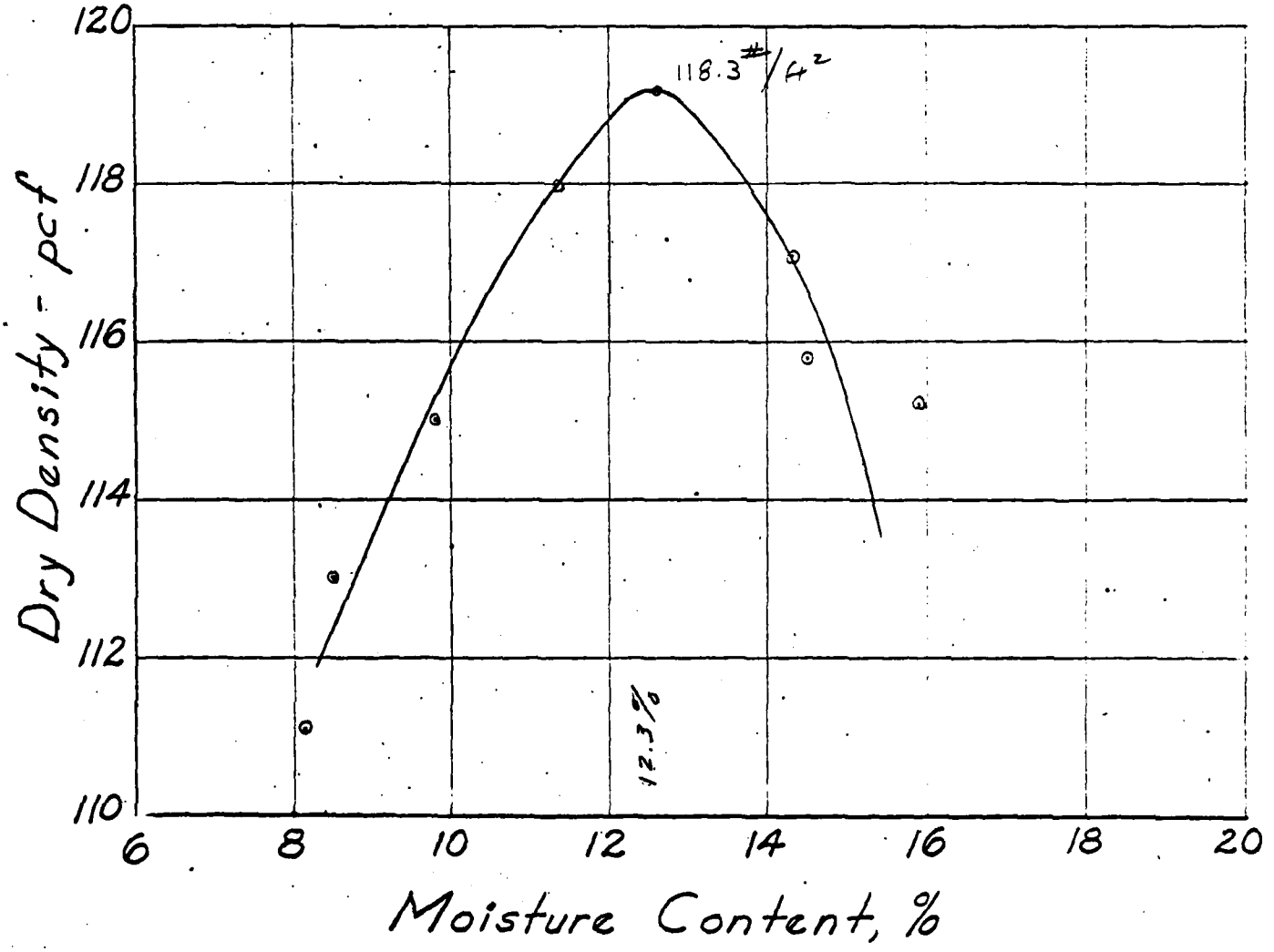
Boring Contractor _____ Foreman _____

Classification by _____

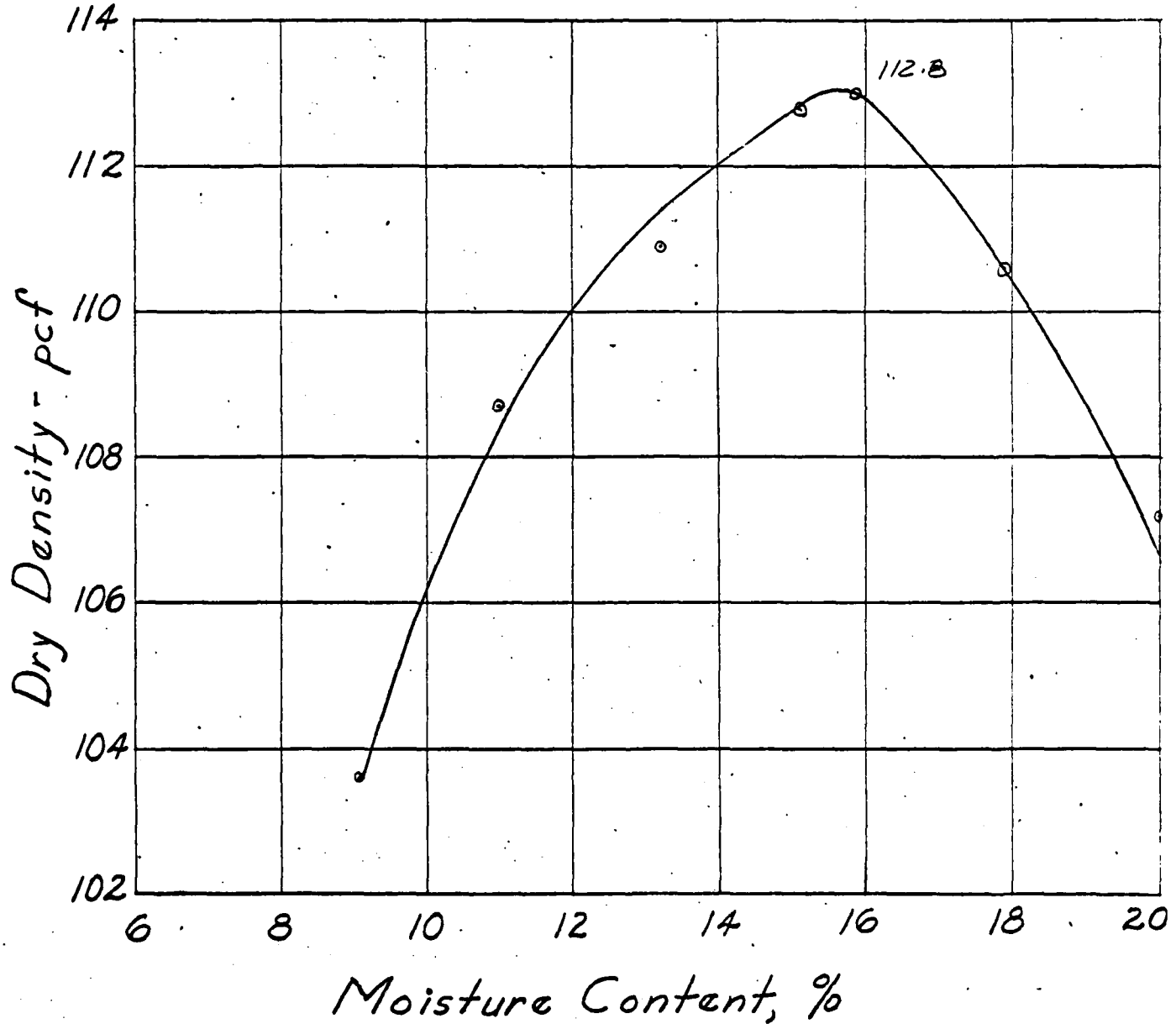
Remarks _____

FIGURE NO. _____

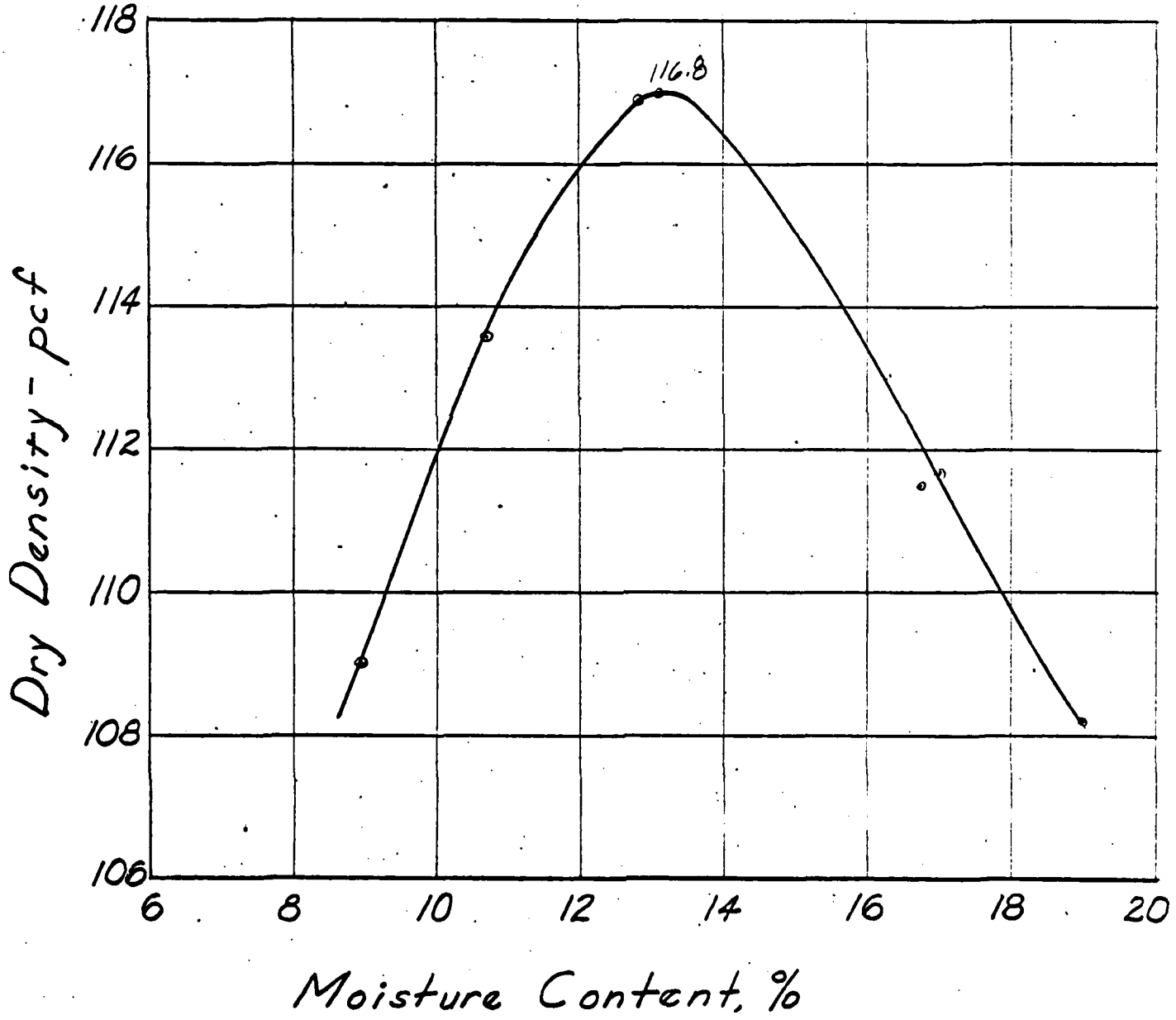
Putnam County Lake
Standard Proctor Test
Boring No 1
October, 1964



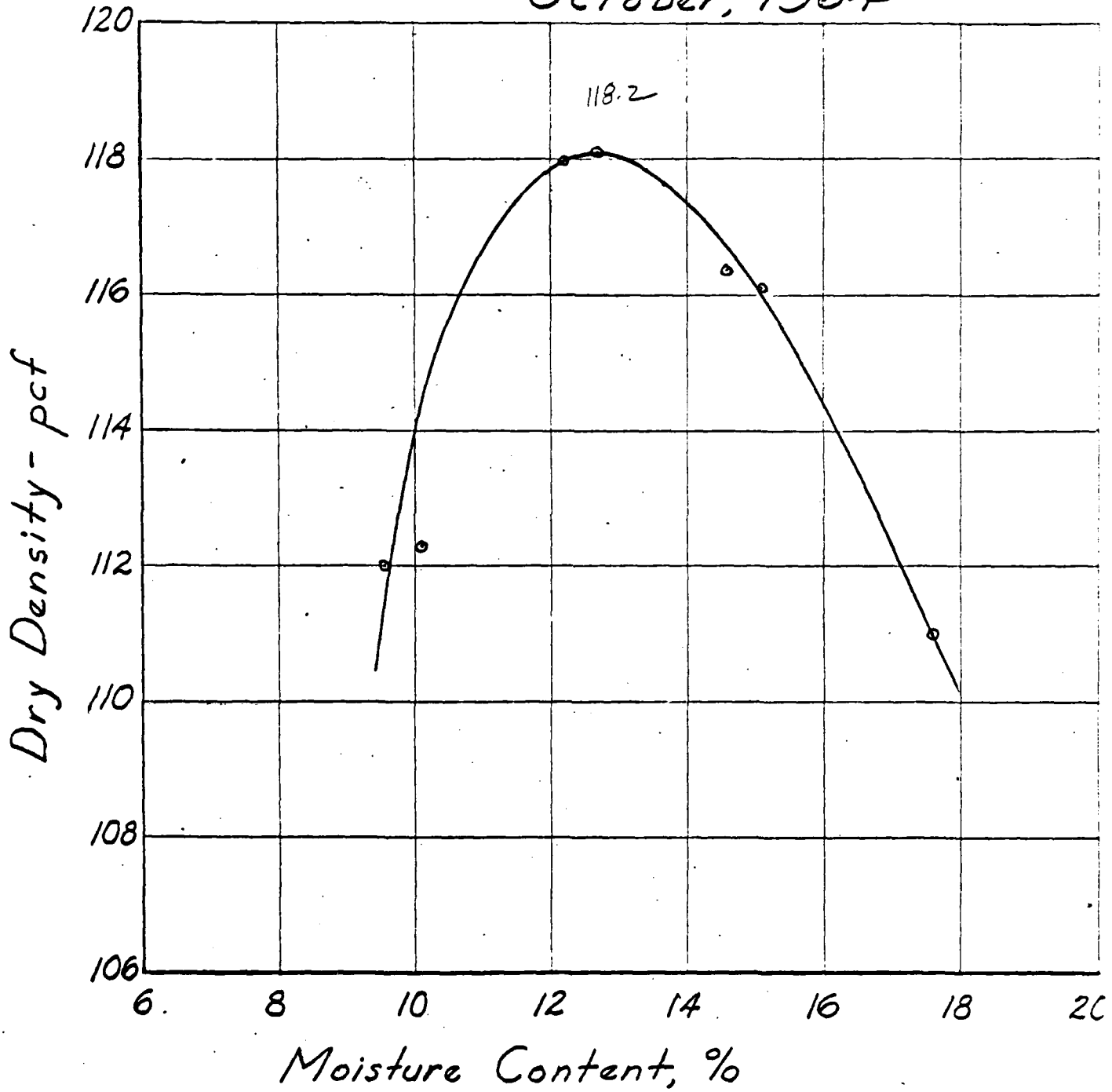
Putnam County Lake
Standard Proctor Test
Boring No 2
October, 1964



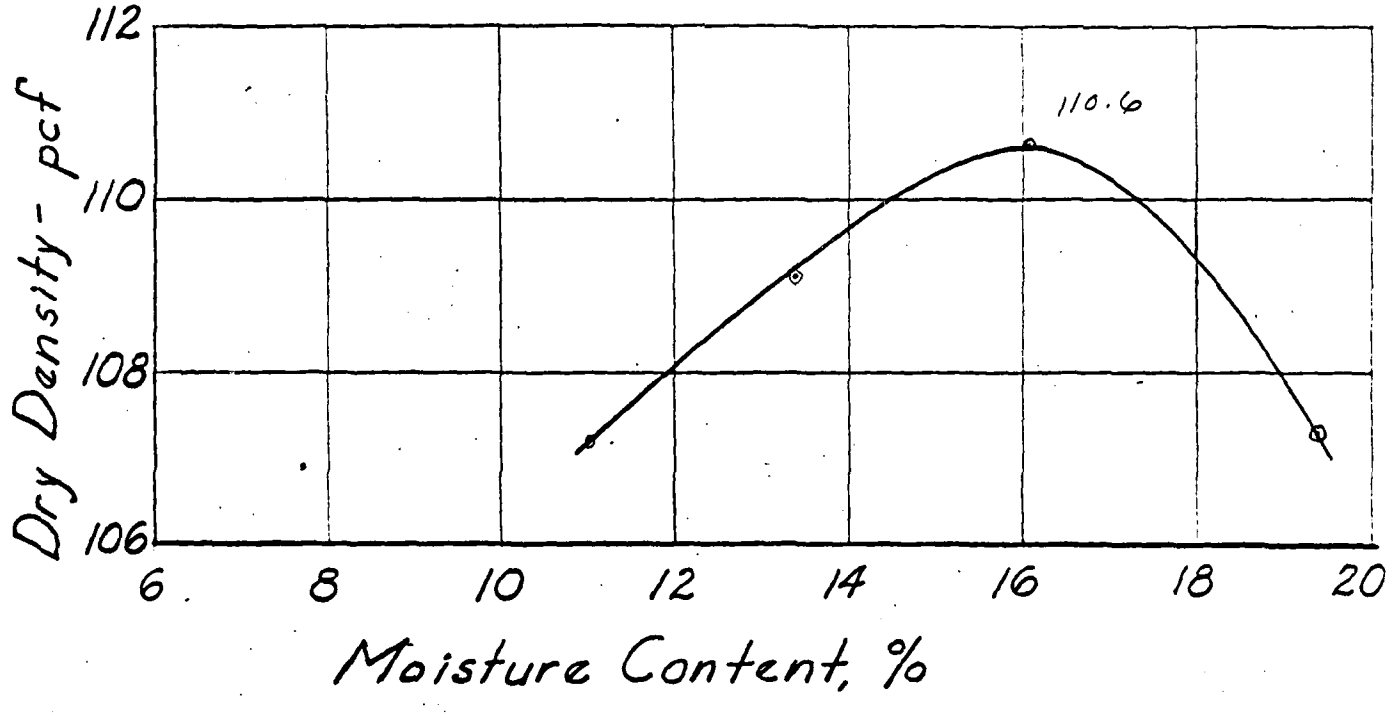
Putnam County Lake
Standard Proctor Test
Boring No 3
October, 1964



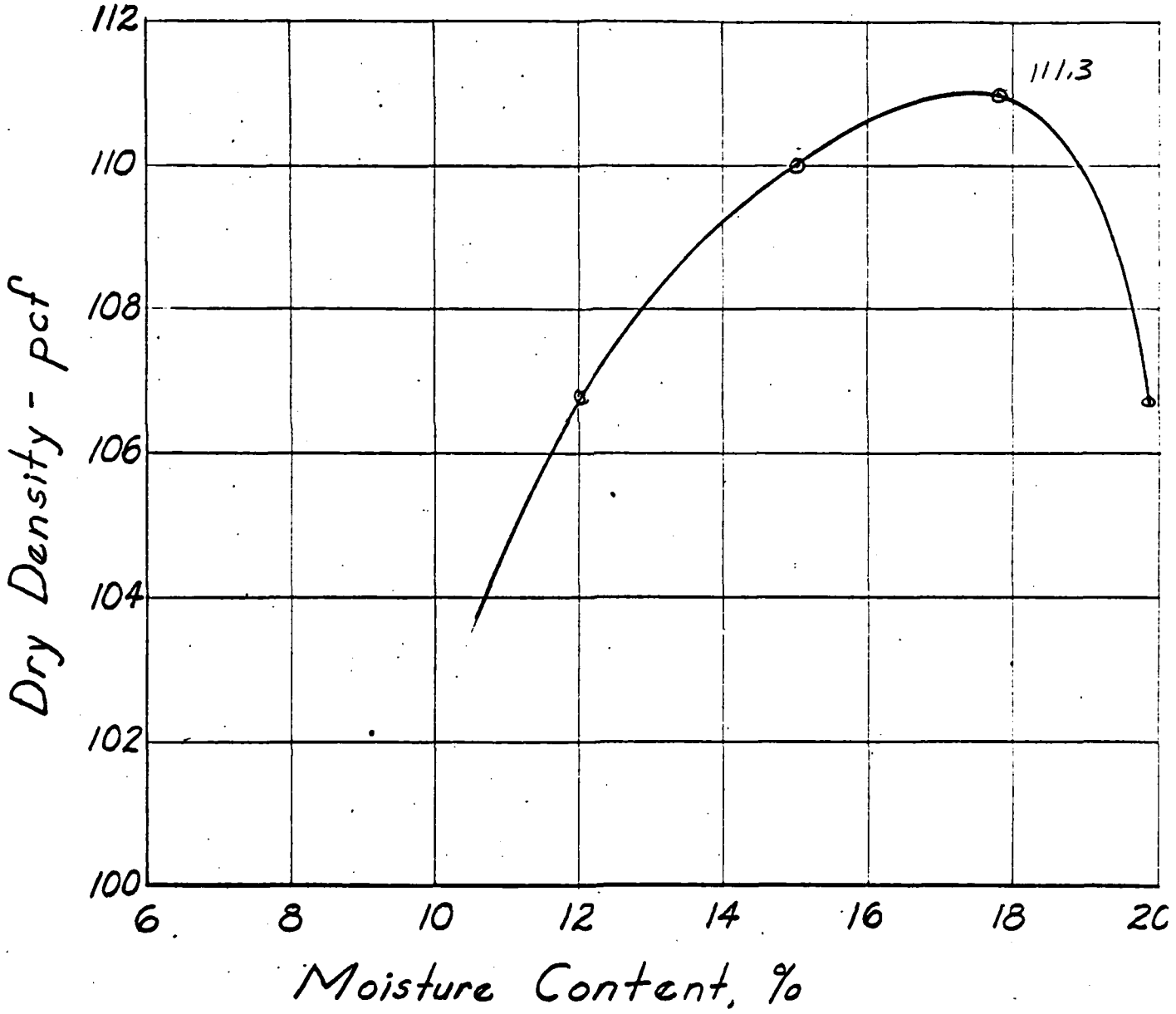
Putnam County Lake
Standard Proctor Test
Boring No 4
October, 1964



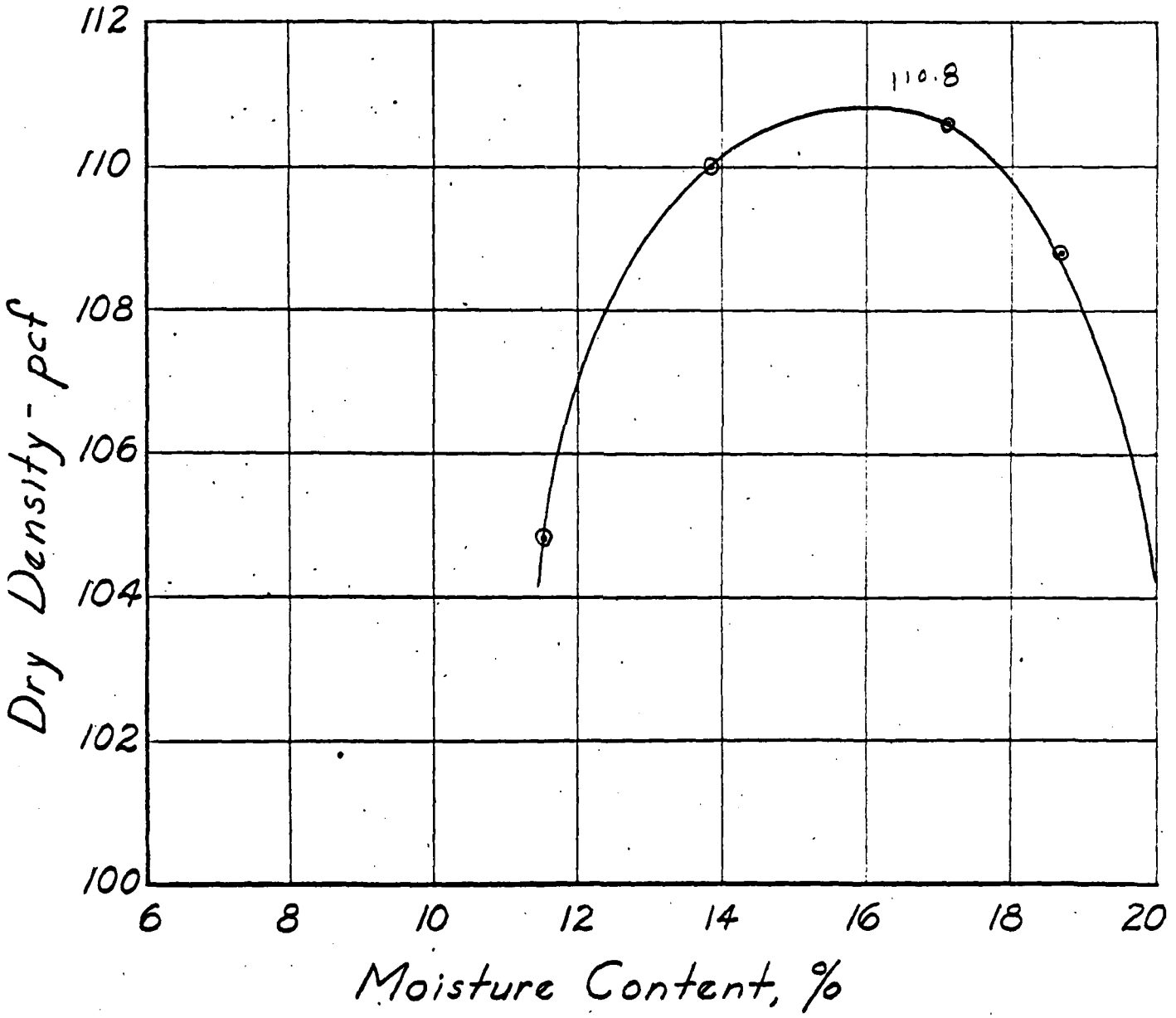
Putnam County Lake
Standard Proctor Test
Boring No 5
October, 1964



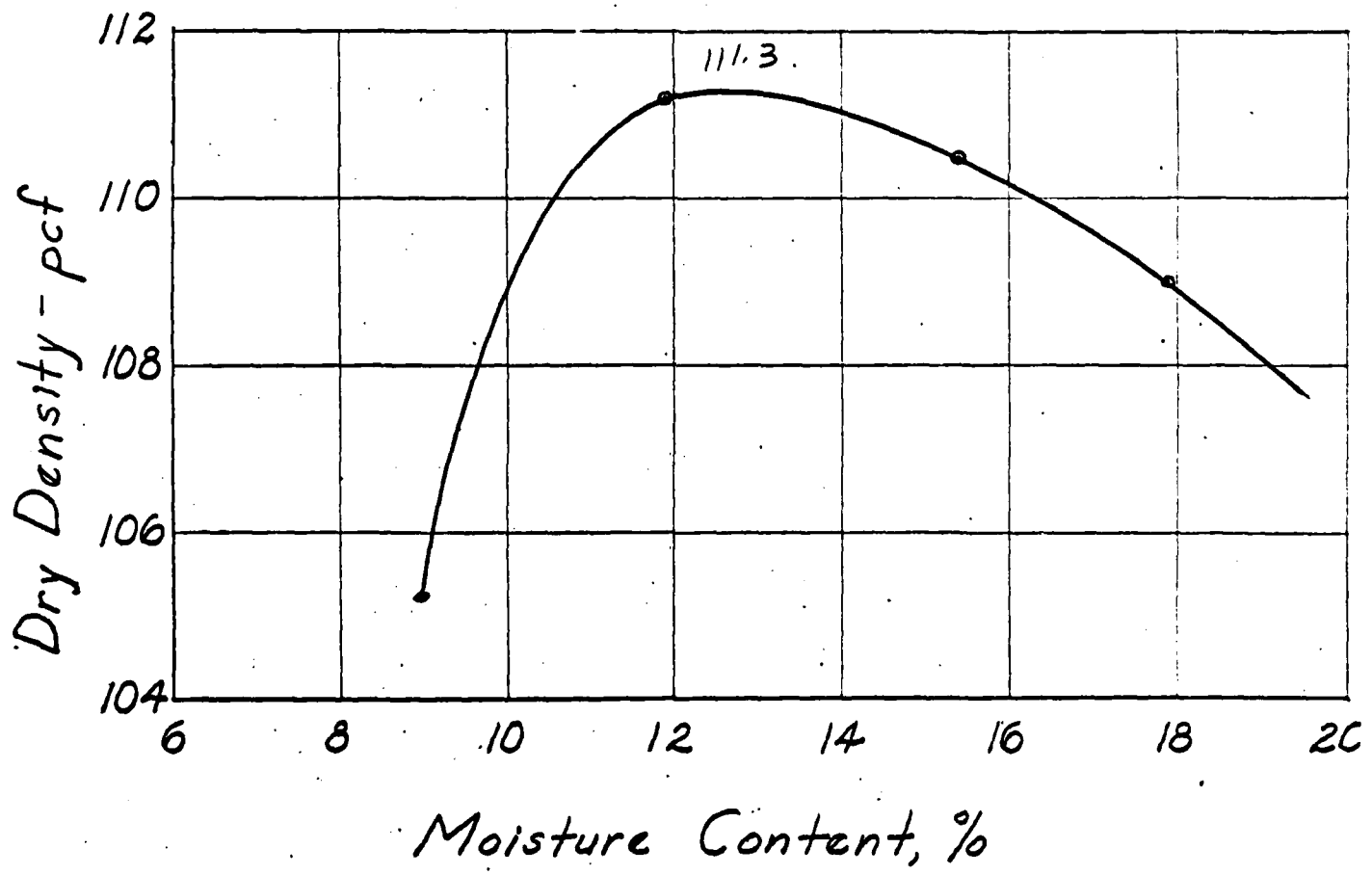
Putnam County Lake
Standard Proctor Test
Boring No 6
October, 1964



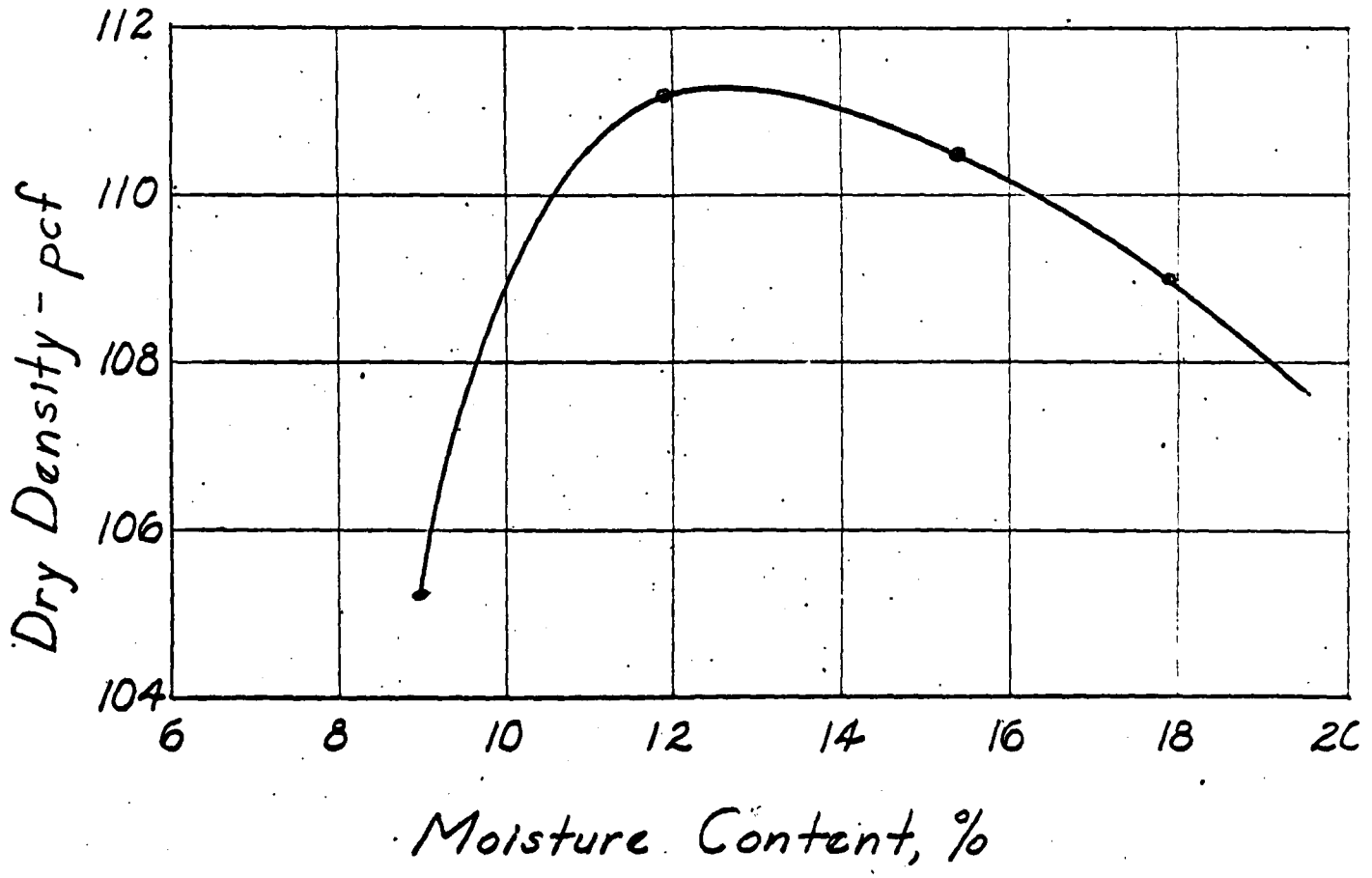
Putnam County Lake
Standard Proctor Test
Boring No 7
October, 1964



Putnam County Lake
Standard Proctor Test
Station 0-372
October, 1964



Putnam County Lake
Standard Proctor Test
Station 0-372
October, 1964



APPENDIX E

DIVISION II

SOIL ANALYSIS, LOG OF SOUNDINGS

AUGUST & SEPTEMBER, 1964

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 1

Project DIONVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by V. DOUGHTY

County FITURN — Date AUG. 27, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
27+12' 3+35			0-10		BROWN CLAY STIFF
			10-26		BROWN SANDY CLAY - STIFF
					PENETRATION TEST
			2'		18 BLOWS PER FOOT
			5'		41 "
			10'		56 "
27+71 5+58			0-14		BROWN CLAY
			14-18		BROWN SANDY CLAY
			18-24		BROWN VERY SANDY CLAY
			24-56		GRAY CLAY
					PENETRATION TESTS
			2'		12 BLOWS PER FOOT
			5'		20 "
			10'		15 "
			15'		20 "
			20'		65 " SMALL ROCK & SANDY CLAY

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

C DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 2

Project UNIONVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by V. DOUGHTY

County PUTNAM — Date AUG 19, 1954

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
7+00			0-13		GRAY SILTY CLAY LOAM
			13-15		GRAY SAND, COARSE GRAVEL & WATER 13'
			15-28		GRAY CLAYEY SAND, SILTY - SOFT & WET
			28-41		GRAY CLAY - STIFF
					PENETRATION TESTS
			2'		11 BLOWS PER FOOT
			5'		7 "
			10'		7 "
			15'		7 "
			20'		5 " SLIGHT RECOVERY

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 3

Project UNIONVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location 3.5 MILES N. UNIONVILLE ON HWY 5 — Soundings by V. DOUGHTY

County PUTNAM — Date AUG 18, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
9+00			0-4		BROWN TO BLACK SILT LOAM - DRY
			4-20		GRAY SANDY SILT - WATER - 7.5'
			20-31		BLACK & GRAY CLAYEY SAND, SILTY - SOFT & WET
			31-41		GRAY CLAY - STIFF
					PENETRATION TESTS
			2'		7 BLOWS PER FOOT
			5'		3 "
			10'		3 "
			15'		3 " SLIGHT RECOVERY
			20'		5 "

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

C DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings. Data Sheet No. 4

Project UNIONVILLE LAKE (Official) Job No.

(Unofficial) Purpose

Location Soundings by V. DOUGHTY

County PUTNAM Date AUG 29, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
10+00			0-5		BROWN SILT LOAM - DRY
			5-10		BROWN SILTY SAND
			10-25		GRAY SILTY SAND
			25-31		GRAY COARSE SAND, GRAVELLY
			31-41		GRAY CLAY
					PENETRATION TESTS
			2'		6 BLOWS PER FOOT
			5'		3 "
			10'		6 "
			15'		3 "
			20'		6 "

Miscellaneous Data

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 5

Project UNIONVILLE LAKE (Official) — Job No.

(Unofficial) — Purpose

Location 3.5 MILES N. UNIONVILLE on Hwy 5 — Soundings by V. DOUGHTY

County FAIRFAX — Date AUG 18, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
11+00			0-4		BROWN TO BLACK SILT LOAM - DRY
			4-9		BLACK SILT LOAM - MOIST - WATER 8'
			9-21		GRAY SANDY SILT - WET
			21-22		GRAY CLAYEY SAND, SILTY - SOFT & WET
			22-34		COARSE GRAY SAND
			34-51		GRAY CLAY - STIFF
					PENETRATION TESTS - STD. SPLIT-SPOON
			2'		7 BLOWS PER FOOT
			5'		8 "
			10'		3 "
			15'		3 "
			20'		5 "
			25'		8 "
			30"		NO RECOVERY - SAND FILLED IN HOLE 2'

Miscellaneous Data

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 6

Project UNIONVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by V. DOUGHTY

County PUTNAM — Date AUG 29, 1966

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
12+00			0-5		BROWN SILT LOAM - DRY
			5-11		BLACK SILT LOAM - MOIST
			11-18		GRAY SANDY SILT - WATER 11'
			18-24		GRAY CLAYEY SAND, SILTY - SOFT
			24-30		GRAY SAND - COARSE (GRAVELLY OR ROCKS AT 26)
			30-41		GRAY CLAY
					PENETRATION TESTS
			2'		5 BLOWS PER FOOT
			5'		2 "
			10'		3 "
			15'		6 "
			20'		HOLE CAVED IN WITH GRAY SAND TO 15'

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 7

Project VIDONVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by V. DAUGHTY

County PUTNAM — Date AUG. 26, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
12+50			0-5		BROWN SILT LOAM - DRY
			5-8		BROWN SILT LOAM - MOIST
			8-24		GRAY SILTY SAND - WATER 8'
			24-44		GRAY SAND, GRAVELLY
			44-56		GRAY CLAY
					PENETRATION TESTS
			2'		BLOWS PER FOOT
			5'		11
			10'		2 11
			15'		5 11
			20'		6 11

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 8

Project UNIONVILLE LAKE (Official) — Job No.

(Unofficial) — Purpose

Location — Soundings by V. DOUGHTY

County PUTNAM — Date AUG. 21, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
13+06			0-5		BROWN SILT LOAM - DRY
			5-10		BROWN SILT LOAM - MOIST-WATER 8'
			10-20		BROWN & GRAY SAND - SILTY
			20-46		GRAY SAND, FINE & SILTY, COARSE 38-46
			46-60		GRAY CLAY
					PENETRATION TESTS
			2'		8 BLOWS PER FOOT
			5'		7 "
			10'		4 "
			15'		4 "
			20'		6 "
12+95					SHELBY TUBE - 3" - SAMPLES
			6'		BROWN SILT LOAM
			13		GRAY SILTY SAND
			18		GRAY SAND
			28		NO RECOVERY - HOLE CAVED IN 95'

Miscellaneous Data

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 9

Project DUNNVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by V. DOUGHTY

County PUTNAM — Date AUG. 26, 1954

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
13+50			0-5		BROWN SILT LOAM - DRY
			5-10		BROWN SILT LOAM - MOIST - WATER 8'
			10-25		GRAY SILTY SAND
			25-41		GRAY CLAY
					PENETRATION TESTS
			2'		2 BLOWS PER FOOT
			5'		6 "
			10'		3 "
			15'		6 "
			20'		7 "

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 10

Project Winonville Lake (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by V. Doughty

County Putnam — Date Aug. 19, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
14+00			0-8		BROWN SANDY CLAY LOAM
			8-14		BROWN SANDY CLAY - WATER 13.5'
			14-15		BROWN SAND & WATER
			15-18		BROWN CLAY
			18-20		BROWN & GRAY CLAY
			20-41		GRAY CLAY
					PENETRATION TESTS
			2'		NO RECOVERY - TREE ROOTS
			5'		7 BLOWS PER FOOT
			10'		14 "
			15'		15 "
			20'		19 "
			26'		100 " FOR 9" - GRAY CLAY

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 11

Project VINCENNES LAKE (Official) — Job No.

(Unofficial) — Purpose

Location — Soundings by W DOUGHTY

County PUTNAM — Date SEPT. 3, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
14+73 ℄	ABT. -2'		0-26		BROWN CLAY — STIFF
			26-41		GRAY SILTY CLAY
					PENETRATION TESTS
			2'		32 BLOWS PER FOOT
			5'		27 "
			10'		14 "
			15'		21 "
			20'		21 "
16+25 ℄	ABT. -2'		0-36		BROWN CLAY
					PENETRATION TEST
			2'		25 BLOWS PER FOOT
			5'		25 "
			10'		20 "

Miscellaneous Data

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

C DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 12

Project UNIONVILLE LAKE (Official) — Job No.

(Unofficial) — Purpose

Location — Soundings by V. DOUGHTY

County PUTNAM — Date AUG 31, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
?			0-5		BROWN SANDY LOAM
UP LEFT			5-5.5		LAYER BROWN SAND
FORK			5.5-8		BROWN & GRAY CLAY - STIFF
			8-11		BROWN SILTY CLAY - WATER 11'
			11-16		BROWN & GRAY CLAY - STIFF
					PENETRATION TEST
			2'		7 BLOWS PER FOOT
			5'		5 "

Miscellaneous Data

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

C

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 13

Project UNIONVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by U. DOUGHTY

County PUTNAM — Date AUG. 31, 1954

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
?					WEST BY CREEK TIMBER - EAST OF FENCE
110 LEFT			0-3		BROWN & GRAY CLAY LOAM
FORK			3-12		BROWN & GRAY CLAY - STIFF
			12-14		BROWN SILTY CLAY - MED. SOFT
			14-17		LAYERS BROWN & GRAY CLAY & SAND - WATER 14'
			17-21		GRAY CLAY - MED. SOFT
			21-26		GRAY SANDY CLAY
					PENETRATION TESTS
			5'		5 BLOWS PER FOOT
			10'		4 "
			15'		3 "
			24-25'		3 " - SOME GRAY SAND CAVED IN
					ABT. 1' OF GRAY SANDY CLAY

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 14

Project VERMONVILLE LAKE (Official) — Job No. _____

_____ (Unofficial) — Purpose _____

Location _____ — Soundings by V. DOUGHTY

County BUTLER — Date SEPT. 1, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
STA. A					RT. OF 11+00 ℄ UPSTREAM
			0-6		BROWN SILT LOAM - DRY
			6-9		BROWN SILT LOAM - MOIST
			9-14		GRAY CLAYEY SAND - WATER 9'
			14-40		GRAY SILTY SAND - ROCKS & GRAVEL 26 to 32
			40-46		GRAY SILTY CLAY - SOFT
			46-51		GRAY CLAY - STIFF
					PENETRATION TESTS
			2'		8 BLOWS PER FOOT
			5'		4 " " "
			10'		4 " " "
			15'		2 " " "
			20'		4 " " "

Miscellaneous Data _____

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings — Data Sheet No. 15

Project UNIONVILLE LAKE (Official) — Job No.

(Unofficial) — Purpose

Location — Soundings by V. DOUGHTY

County PUTNAM — Date SEPT. 1, 1944

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
"8"			0-8		BROWN SILT LOAM - DRY
			8-15		BROWN SILTY SAND - WATER 8'
			15-18		GRAY CLAYEY SAND
			18-29		GRAY SILTY SAND
			29-35		GRAY SILTY CLAY - SOFT
			35-41		GRAY CLAY - STIFF
					PENETRATION TESTS
			2'		8 BLOWS PER FOOT
			5'		7 " " "
			10'		4 " " "
			16'		6 " " "
			21		6 " " "

Miscellaneous Data

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings

Project UNIONVILLE LAKE (Official)

(Unofficial)

Location

County PUTNAM

Data Sheet No. 16

Job No.

Purpose

Soundings by V. DOUGHTY

Date SEP. 2, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
"9"					
			0-6		BROWN SILT LOAM - DRY
			6-11		BROWN SILTY CLAY LOAM - WATER 11'
			11-20		GRAY SILTY CLAY
			20-30		GRAY CLAYEY SAND
			30-41		GRAY CLAY
					PENETRATION TESTS
			2'		6 BLOWS PER FOOT
			5'		4 "
			10'		4 "
			20'		5 "

Miscellaneous Data

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

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C DEVELOPMENT SECTION C

SOIL ANALYSIS

Log of Soundings

Project UNIONVILLE LAKE (Official)

(Unofficial)

Location

County PITTMAN

Data Sheet No. 17

Job No.

Purpose FOR AREA

Soundings by V. DOUGHTY

Date AUG. 25, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
NO. 1			0-50		BROWN CLAY, SLIGHTLY SANDY -
					SMALL SAND POCKETS ABT. 12 & 26
NO. 2			0-46		BROWN CLAY, SLIGHTLY SANDY
NO. 3			0-46		BROWN CLAY, SLIGHTLY SANDY
NO. 4			0-20		BROWN CLAY, SLIGHTLY SANDY
			20-24		BROWN SAND - WET
			24-30		BROWN CLAY
			30-34		BROWN SAND - WET
			34-40		BROWN CLAY

Miscellaneous Data VERY SMALL AMOUNT OF GRAY CLAY IN NO. 4 SOMEWHERE ABT. 24-35, POSS. ONLY FEW INCHES THICK.

+ Distances given from centerline are perpendicular thereto unless otherwise noted.

* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

DEVELOPMENT SECTION

SOIL ANALYSIS

Log of Soundings

Project [illegible] LAKE (Official)

(Unofficial)

Location

County [illegible]

Data Sheet No. 18

Job No.

Purpose [illegible]

Soundings by [illegible]

Date SEPT. 5, 1964

Station	Loc.+	Surf. Elev.	Depth	Bott. Elev.	Log of Materials*
0-372					ON & IN EMER SPILLWAY
			0-11		BROWN CLAY
			11-13		BROWN SANDY CLAY
			13-16		BROWN CLAY
			16-25		BROWN CLAYEY SOIL - WET
(5)			0-25		BROWN CLAY
(4)			0-25		BROWN CLAY - SANDY STONE
(7)			0-25		BROWN CLAY

Miscellaneous Data

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* Persons using this information are cautioned that the materials shown are determined by the equipment noted and accuracy of the "Log of Material" is limited thereby and by judgment of the operator. Log of operations is an integral part of this information.

APPENDIX E

DIVISION III

GEOLOGIC REPORT, MISSOURI GEOLOGICAL SURVEY

1963

INSPECTION REPORT, MISSOURI GEOLOGICAL SURVEY

1972

ENGINEERING GEOLOGIC REPORT, MISSOURI

GEOLOGICAL SURVEY

1978

Prepared by James A. Martin and James H. Williams
Missouri Geological Survey - 1963

GEOLOGIC REPORT ON THE PROPOSED PUTNAM COUNTY LAKE SITES
NEAR UNIONVILLE, MISSOURI

A surface geologic study of two lake sites near Unionville, Missouri, was made for the Putnam County Jaycees. Of the two sites, the most favorable is the North Site located on Blackbird Creek north of Unionville. The dam site is upstream (west) of Missouri Highway 5. The South Site on South Blackbird Creek west of Highway 129 is less suitable since bedrock openings and mine drifts indicate exploration and construction costs would be greater than at the North Site. Each lake site would have approximately 1200 surface acres of water.

North Site: This site used K-50

Both the abutments and the impoundment area will be in glacial drift. An examination of the area showed bedrock to be buried at depth by glacial drift. A water height of 60 feet at the dam site will create a lake area of about 1200 acres. The drainage area is estimated to be 18,000 acres. The location of the dam site is in the SW 1/4, SE 1/4, Section 10 and NE 1/4, NE 1/4, Section 15, T. 66 N., R. 19 W. All geologic features point to a safe lake at this site with regards to possible water loss to the bedrock.

Water loss hazards at the site are related to the glacial drift and alluvium. Possible loss would be through sand bodies in the abutment and underflow through the alluvium or glacial sands in Blackbird Creek. Ramdom, isolated sand bodies are known to be present in glacial drift. Although none were observed, it is recommended that the abutments be augered to determine the glacial drift characteristics. Exploration along

EXHIBIT "B"

the center line across Blackbird Creek should be made to determine the characteristics of the valley alluvium. Because the valley alluvium has been deposited by running water there may be sand and gravel zones interlayed with silt and clay beds. Therefore, underflow through pervious sands and gravels beneath the dam is a major hazard if not intercepted by the core trench or a cut off curtain. Support characteristics of the foundation material may vary across the valley because of its alluvial origin.

South Site:

The dam site is in the NE 1/4, SW 1/4, SW 1/4, Section 22, and NW 1/4, NW 1/4, NW 1/4, Section 27, T. 65 N., R. 18 W., on South Blackbird Creek, west of Missouri Highway 129. Bedrock, exposed upstream and downstream from the damsite, dips toward the northeast. Limestone, shale and coal beds are covered by a thin veneer of soil on the abutments. Bedrock belongs to the Pennsylvanian system and includes formations from the Fort Scott-Higginsville limestone-up to and including the Altamont-Worland limestone. The section is a series of alternating thin limestone beds 1 to 4 feet in thickness interlayered with shale and coal beds. A number of mine drifts were observed along the valley of the lake and in Kinney valley to the north of the left abutment. Small underground mining operations are presently active in the area.

Potential water loss from the lake to the bedrock may occur at the abutments and in the upstream area. Such loss would be via bedding plains and joints in the limestone units. Because of the intensified

File Only

ADDENDUM TO LAKE THUNDERHEAD

Putnam County, Missouri

Inspection of Lake Thunderhead on 8 May 1972, indicates the following:

1) Seepage on the left abutment slope is apparently more extensive than previous times of investigation. An area approximately 100 feet square is water saturated. The water is present as surface flow gradually seeping through what is apparently a lense of sandy loam soil that makes up at least a portion of the left abutment.

2) The lagoons, although water filled, apparently are severely affected by subsurface water seepage. Water in the lagoons seems to be mostly that which would be derived from the water bearing gravels and sands that were exposed during lagoon construction.

3) The interception ditches do not appear to be functioning. Consequently, seepage from the dam has water saturated much of the upstream portion of the lagoon levees outside of the lagoon as well as contributed to a portion of the water within the lagoons.

4) A significant amount of water seepage is welling up in the manhole present where the sewer line has been constructed under the dam.

James H. Williams
Geologist and Chief
Engineering Geology Section
Missouri Geological Survey and
Water Resources
May 17, 1972

FOR FILE ONLY

ENGINEERING GEOLOGIC REPORT ON LAKE THUNDERHEAD

PUTNAM COUNTY, MISSOURI

LOCATION: NW¼, NE¼, NE¼, Sec. 15, T. 66 N., R. 19 W., Seymour Quadrangle.

The dam site was selected by J.A. Martin-J.H. Williams in 1963. It has served the purpose well except for financial problems of the developers.

One point not observed in the original investigation and later drilling by the Conservation Commission and engineers was the significance of a terrace on the left, north, abutment. A line of seepage has persisted on the eastern portion of this terrace some 200-300 feet from the lake. Water movement is being controlled by the stratified terrace deposits. Leakage has remained unchanged for the past 5 to 6 years. It does not appear to pose a threat to the dam.

Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Geology & Land Survey
August 23, 1978


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